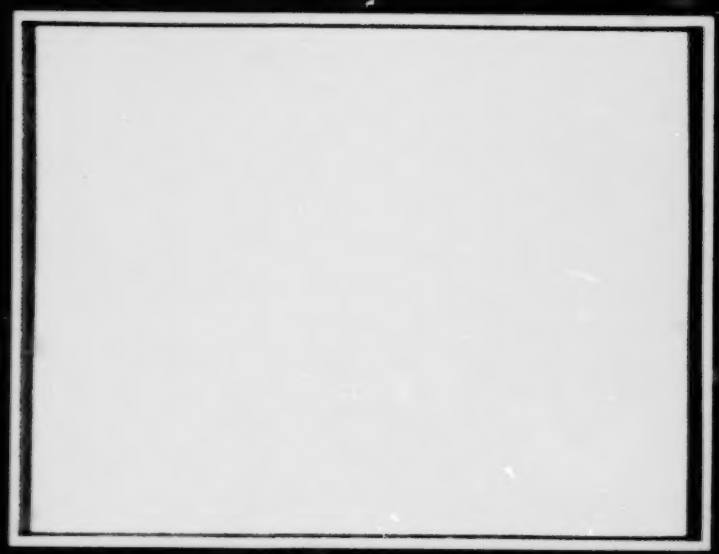


CREDA

Test and Tune

CREDA is a program which has been jointly funded by Energy, Mines and Resources, Canada and the Yukon Government, Department of Economic Development. For more information or copies of reports contact the Energy Branch, Yukon Government, Box 2703, Whitehorse, Y1A 2C6, (403) 667-5471.

Table of Contents

	Page
Foreword	i
Preface	ii
Executive Summary	iv
Resumé	vi
The "Test and Tune Program	1
Air Quality Analysis	21
Analysis of Whitehorse Fuel Sales Data	40
Appendices	82
Final Summary Sheet	105

Foreword

The availability of secure and affordable energy supplies is a subject of national concern. Our primary energy sources are becoming more costly and less accessible. However, Canada has both the resources and technical expertise needed to develop renewable and alternate success of energy.

The governments of Yukon and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement as one means of pursuing this end. Cost shared by the territorial and federal governments, CREDA has a budget of $3.3 million and is dedicated to the development and demonstration of conservation and renewable energy technologies.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

The car clinic project which is reported on in the following pages is an important attempt to develop broad public awareness of the variables which effect fuel efficient vehicle operation. A large proportion of Canada's energy resources are expended in the propulsion of private vehicles powered by internal combustion engines. This project and others undertaken in different jurisdictions might significantly reduce the waste of fuel involved in this mode of transportation.

Preface

In the summer of 1981 a free clinic was offered to the people of Yukon to improve automobile efficiency and reduce hydrocarbon and carbon monoxide emisions, primarily by means of proper carburetor adjustment. Approximately one quarter of Yukon's vehicles were brought in for inspection and adjustment.

Two different methods were used in an attempt to verify the efficacy of the treatment:

- the monitoring of specific vehicles' fuel consumption before and after adjustment; and
- the comparison of community gasoline sales and ambient atmospheric carbon monoxide levels for the winters before and after the project.

With the former method a small number of vehicles were directly measured, and most vehicles showed a substantial reduction in fuel consumption. The fuel flowmeter data (derived from 21 tests on individual vehciles immediately before and after adjustment) indicated a 6% fuel saving. A group of 18 vehicles from the NorthwesTel fleet showed a 10% fuel saving in the 3 month period following Test'n' Tune, compared with a control group of twelve vehicles monitored throughout the same period. In other words, the direct monitoring of the actual participants showed that it is a good idea to keep a vehicle's carburetor properly adjusted.

The latter method involved looking for a needle in a haystack. Not surprisingly, it was not possible to find a statistically significant correlation between fuel sales in January '81 and January '82 which could verify the expected 1-2% decrease in fuel consumption by the community, amongst such other factors as changing fleet characteristics, economic activity, weather and the indeterminable vagaries of human behavior that accompany all of the above.

The average vehicle reduction in carbon monoxide emissions at idle was 44%. From this one could expect a drop in the ambient CO level of no more than 10%. The actual drop of 34% is a function not only of Test and Tune but also of the depth and intensity of the winter inversion, wind, driving habits and most importantly woodstoves.

The lack of a statistically significant correlation between community gasoline sales and the Test'n' Tune Project indicates a shortcoming in the monitoring process, rather than a failure of carburetor adjustment to effect fuel savings. The inability to find a needle in a haystack is not a proof that it is not there.

Robert E. Collins
Manager
Conservation and Renewable
Energy Demonstration Program

EXECUTIVE SUMMARY

Investigations by Environment Canada personnel have indicated that the majority of automobiles and trucks in daily use across Canada are not properly tuned for lowest fuel consumption and emissions. Typically, only 30% of the vehicles sampled in numerous provincially-sponsored surveys have been found to be within acceptable limits for carburetor idle mixture adjustment. Among the failing vehicles, approximately 70% could be brought into line with manufacturers' specifications with nothing more than a simple carburetor adjustment.

It has been shown that production vehicles, when tuned to manufacturers' specifications are capable of meeting federally-mandated vehicle emission standards[1]. Deviation from the idle mixture setting recommended by the manufacturer, however, causes emissions and fuel consumption to increase significantly. The average maladjusted vehicle will emit 30-50% more carbon monoxide, 10-30% more hydrocarbons and consume 2-10% more fuel than it would if properly adjusted[2]. The degree of excess emissions and fuel consumption depends on the vehicle duty cycle. An excessively rich idle air-fuel mixture will have a large effect on fuel consumption at idle and at low speed (i.e. under 40 kph) but only a minimal effect at highway speeds.

In 1980, it was proposed that a demonstration project be set up in Whitehorse, Y.T. in order to assess the impact on air quality and fuel consumption attainable with an inspection/maintenance program. It was felt that the Whitehorse site was ideal for such a project because it is a fairly small, isolated community with a relatively stable vehicle population, especially during the winter months, for which reliable air quality readings are available. Also, the geographic location of Whitehorse leads to atmospheric conditions which cause ambient carbon monoxide levels to be quite high in winter. As automobiles are the principle source of CO emissions in the area, it was felt that the impact of inspection and maintenance would be easily identified because a large proportion of the total vehicle population could be inspected and adjusted for minimum emissions and fuel consumption during the summer and the changes in ambient CO levels and gasoline sales could be monitored through the winter. With the co-operation of the Government of Yukon, the city of Whitehorse and the federal departments of Energy, Mines and Resources and Transport the "Test and Tune" program began on June 15, 1981.

Of the estimated 15,000 vehicles in Whitehorse, 3512 were involved in the program. Of these, only 32.9% were found to be in proper tune before adjustment. Even though 86% of the failing vehicles were adjusted by the on-site technicians, only 60.5% of

the fleet left the inspection centre at spec. This result indicates that many vehicles could not be properly adjusted because of other engine problems. However, in every case the idle mixture was adjusted to the leanest point at which the engine would run properly.

For the inspected vehicles, the concentration of carbon monoxide in the tailpipe exhaust was reduced on average from 2.5% to 1.4%; almost 50%.

Given the traffic conditions in Whitehorse and the tendency to leave unattended vehicles idling for long periods in cold weather, it was expected that a measureable improvement in air quality would be observed as a result of "Test and Tune". Similarly, it was felt that gasoline sales in the city would be reduced as well.

Environment Canada maintains an air quality monitoring station in the Federal Building in Whitehorse. Ambient CO readings during the winter months following the "Test and Tune" program were compared to the same period for the previous three years. At the same time, historical gasoline sales were compared to those for the period following "Test and Tune".

Analysis of this data indicated a 34% reduction in ambient CO attributable to the program but gasoline sales in the city for the same period did not show a statistically significant reduction.

Given the reduction in CO% for the inspected vehicles, these results are not surprising. If one considers that probably less than half of the vehicles in Whitehorse were inspected and that the maximum savings in fuel consumption anticipated for the adjusted fleet would be less than 10%, small change in fuel sales would be expected. Due to the fact that the error tolerances associated with the data are so large, a statistically valid result would not be expected. The air quality data, however, is consistent with what would be expected from such a program.

Résumé

Des recherches menées par les employés du ministère fédéral de l'Environnement ont indiqué que la majorité des automobiles et des camions en usage quotidien partout au Canada ne sont pas mis au point assez finement pour réaliser le taux le plus bas de consommation et d'échappement. D'une façon typique, 30% seulement des véhicules examinés dans de nombreuses enquêtes menées par les provinces se sont situés dans les limites acceptable en ce qui concerne le réglage du mélange carburé. Parmi les véhicules défectueux, 70% environ pourraient être amenés en conformité avec les spécifications des fabricants sans autre intervention qu'un simple réglage du carburateur.

Il a été démontré que lorsque les véhicules sont réglés au départ de production selon les spécifications des fabricants, ils peuvent atteindre les normes d'émission imposées par les autorités fédérales. Toute déviation du niveau recommandé par le fabricant pour le mélange carburé au ralenti causera au contraire un accroissement sensible des émissions et de la consommation de carburant. Le véhicule malréglé moyen émettra de 30 à 50% de plus d'hydrocarbures et consommera de 2 à 10% de plus de carburant que s'il était bien réglé. Le degré d'excès en émissions et consommation de carburant dépend du facteur d'utilisation. Un mélange carburé excessivement riche aura un grand effet sur la consommation de carburant au ralenti et à basse vitesse (c'est à dire au dessous de 40 km/h) mais seulement un effet minime aux vitesses de grand route.

En 1980, on a proposé d'établir un projet à fins de démonstration à Whitehorse, Y.T., pour évaluer le degré d'impact d'un programme d'inspection et d'entretien sur la qualité de l'air et la consommation de carburant. On a jugé que Whitehorse était un site idéal pour un projet de cette sorte parce-que c'est une assez petite agglomération isolée avec un nombre relativement stable de véhicules, surtout pendant les mois d'hiver, et où on peut obtenir des mesures sûres et précises de la qualité de l'air. De plus, la situation géographique de Whitehorse entraîne des conditions

atmosphériques qui occasionnent des niveaux ambiants d'oxyde de carbone très élevés en hiver. Les automobiles étant la principale source d'émission de CO dans la région, on était d'opinion que l'impact de l'inspection et de l'entretien serait facilement déterminé du fait qu'une grande proportion du nombre total des véhicules pourrait faire l'objet d'inspection et de réglage, pendant l'été, en vue d'amener les émissions et la consommation de carburant au minimum, et que les changements affectant les niveaux de CO et la vente de l'essence pourraient être contrôlés pendant l'hiver. Avec la coopération du gouvernement du Yukon, de la municipalité de Whitehorse et de deux départements fédéraux - l'Energie, Mines et Ressources ainsi que les Transports - le programme "Vérification et Réglage" (Test and Tune) fut inauguré le 15 juin 1981.

D'un nombre total de véhicules évalué à 15,000 pour Whitehorse, 3512 ont participé au programme. De ceux-ci, 32.9% seulement se sont révélés au point avant le réglage. Bien que 86% des véhicules qui n'étaient pas au point aient été réglés par les techniciens disponibles sur place, 60% seulement de ceux-ci ont quitté le centre d'inspection dans un état correspondant aux spécifications. Ce résultat indique que beaucoup de véhicules ne pouvaient être réglés convenablement par suite d'autres problèmes affectant leur moteur. Cependant, dans tous les cas, le mélange carburé a été réglé au niveau le plus économique de fonctionnement du véhicule.

Pour les véhicules ayant fait l'objet de cette inspection, la concentration d'oxyde de carbone dans le tuyau d'échappement fut réduite en moyenne de 2.5% à 1.4%, presque de 50%.

Etant donné les conditions de la circulation à Whitehorse et la tendance, par temps froid, à laisser tourner le moteur des voitures en stationnement quand on en sort, même pour des périodes prolongées, on s'attendait à observer une amélioration sensible de la qualité de l'air par suite du programme. On pensait de même que les ventes d'essence seraient également réduites dans la ville.

Le ministère fédéral de l'Environnement a une station de contrôle de la qualité de l'air dans l'édifice fédéral de Whitehorse. On a comparé les niveaux de CO ambiant pendant les mois d'hiver succédant au programme "Vérification et Réglage" à ceux de la même période des trois années précédentes. On a également comparé les ventes d'essence enregistrées précedemment à celles d'après le programme.

L'analyse de ces données a indiqué une réduction de 34% du CO ambiant, qu'on pouvait attribuer au programme, mais les ventes d'essence n'ont pas révélé de baisse qui soit statistiquement appréciable.

Etant donné la réduction du taux de CO pour les véhicules inspectés, ces résultats ne sont pas surprenants. Si l'on considère probable que moins de la moitié des véhicules de Whitehorse ont été inspectés et que l'économie de consommation d'essence anticipée pour ce nombre de voitures aurait été au-dessous de 10%, la variation des ventes d'essence à prévoir serait faible. Du fait que les tolérances d'erreur correspondant à ces données sont tellement grandes, on ne s'attendrait pas à un résultat qui soit statistiquement valide. Les observations sur la qualité de l'air, cependant, sont compatibles avec les prévisions auxquelles le programme avait donné lieu.

THE "TEST AND TUNE" PROGRAM

1 INTRODUCTION

The city of Whitehorse, Y.T. is unique to other urban centres in Canada in that it is an isolated community with a relatively stable vehicle population, especially in the winter months. Also, Whitehorse tends to exhibit high levels of ambient CO during the winter primarily because of the number of vehicles left idling for extended periods. This is due to a reluctance on the part of owners to turn off their vehicles while running short errands when the weather is very cold.

It was proposed in affiliation with Energy, Mines and Resources Canada, the Government of Yukon and Transport Canada that an inspection/adjustment program be conducted in Whitehorse with a view to reducing the amount of fuel consumed by vehicles in the city and to improving ambient air quality. The results of other programs run by the Mobile Sources Division have indicated that idle CO emissions and fuel consumption may be significantly reduced for most vehicles with a simple adjustment of the carburetor idle mixture screws.

Average vehicle speeds in downtown Whitehorse are quite low so that the idle circuit is dominant in urban vehicle operation. Therefore, a reduction in idle fuel flow would be expected to produce a measureable improvement in overall fuel consumption.

Carbon monoxide emissions are usually higher at idle than at other engine speeds. These emissions increase drastically as the idle fuel/air mixture is made richer. Consequently, a small group of vehicles with improperly adjusted carburetors can produce a disproportionatly high amount of CO emissions.

1.1 Project Support

The program attracted support from a number government agencies at the Federal, Territorial and Municipal level. Energy, Mines and Resources were interested in the energy conservation aspect of the program, Transport Canada and Environment Canada in the emissions and fuel consumption saving, and the Yukon Territorial Government in promoting vehicle operating practices which could lead to reduced fuel costs for residents.

At the municipal level, the city of Whitehorse acted as financier for the project, keeping track of expenses and issuing funds as required. A team of technicians to perform the on site adjustments and record other vehicle information was hired by the site supervisor, Mr. Chuck Suley who was automotive instructor at the Yukon technical college prior to taking over the "Test and Tune" project on a contract basis. Promotional

items such as radio commercials, pamphlets, bumper stickers and even the "Test and Tune" name were devised by Jan Harvey and Associates, a local advertising firm.

The program was conducted from June 12 to September 18 1981. Test lanes were operated full-time at the vocational school site and part-time at a variety of other locations in the Whitehorse area in order to make the program more accessible to residents. At the request of the territorial government, test lanes were operated for one week periods at five smaller communities in the Yukon; Mayo, Faro, Dawson City, Watson Lake, and Haines Junction. Hours of operation and the number of lanes available were adjusted to suit the demand.

1.2 Objectives

In summary, the objectives of the program were:

1. To bring about a reduction in ambient carbon monoxide levels in Whitehorse by reducing the idle CO concentration of as many vehicles as possible.
2. To increase public awareness of the factors affecting fuel consumption, and to advise motorists of steps that could be taken to improve the fuel consumption performance of their vehicles.
3. To permit some motorists to witness directly, by means of a fuel flowmeter and also by the longer term mailback program, the fuel savings possible from proper carburetor adjustment.
4. To characterize the fleet in Whitehorse with respect to composition and emission performance.
5. To bring about a measureable decrease in energy consumption (i.e. gasoline sales) in the Whitehorse area.

2 TEST PROCEDURE

2.1 Equipment

Sun EPA-75 portable infra-red hydrocarbon (HC) and carbon monoxide (CO) analyzers were used for the emissions measurements. Inductive pickup tachometers were used to measure engine rpm.

2.2 . Test Method

The "hi-lo" idle test as described below was used for all vehicles

1. Vehicle to be tested should be at operating temperature.
2. Connect tachomoter and check calibration of the exhaust emission analyzer (CO-HC).
3. Insert the sample line at least 0.6 m into the tailpipe. When this is not possible, a tailpipe extension should be used. In the case of dual exhaust, either tailpipe can be selected. When exhaust system leaks are obvious, the vehicle should not be tested until repair work is done.
4. Disable the air injection/induction system (as a carburetor is adjusted rich, there is a point on catalyst-equipped vehicles where there is insufficient oxygen to allow the catalyst to function. Injected (or inducted) air extends this point such that it is impossible to identify an over-rich condition with an idle HC-CO test).
5. With transmission in park or neutral, increase engine speed to 2500 rpm for at least 30 seconds until CO and HC readings have stabilized. Record HC and CO.
6. Return engine to free idle. Record stabilized readings of HC, CO and rpm (after at least 10 seconds). If rpm is above 1000 and if this reading is not the recommended idle rpm, the emission readings should be considered invalid.
7. Disconnect test equipment and ensure vehicle air system is reassembled.

2.3 Pass/Fail Criteria

Limits for HC and CO emissions were set for each vehicle according to the following determining formulae:

$$\text{CO (\%) idle emission limit} = 0.5 + \frac{\text{vehicle age (years)}}{10} + 2.0 \text{ (if 4 cyl. or rotary)}$$

OR

$$= \text{label spec.} + \frac{\text{vehicle age (years)}}{10}$$

HC (ppm) idle emission limit = 300 + (30 x vehicle age (years))

OR

= label spec. + (30 x vehicle age (years)).

CO (%) 2500 rpm $= 0.3 + \frac{\text{vehicle age (years)}}{10} + 0.5$ (if 4 cyl. or rotary)

OR

$= \text{label spec.} + \frac{\text{vehicle age (years)}}{10}$

Carburetor adjustments were made when necessary in order to bring HC and CO emissions into line with the in-use vehicle standards shown above or to a point at which the emissions were at their lowest level without misfire or excessive engine roughness.

2.4 Data Sheets

In addition to the emission information, other vehicle data such as model year, manufacturer, size, number of cylinders, etc, was recorded on the data sheet. A sample data form is included in Appendix B.

2.5 EGR Valve Check

Environment Canada studies have shown that an inoperative exhaust gas recirculation (EGR) valve can cause NO_x emissions to double over the urban and highway dynamometer emission tests. In order to assess the extent of EGR valve failure or tampering in Whitehorse, a quick check of the valves operation was done as follows:

Ensure that:

1) the engine is fully warmed-up, clamp the vacuum hose to the EGR valve, accelerate the engine to 2500 rpm then release the clamp on the EGR hose. Engine rpm should drop momentarily by at least 100 rpm if the valve is operating properly

OR

2) If it is possible to feel the diaphragm of the valve, quickly open and release the throttle. The diaphragm should move. If it does not, the valve is not working.

2.6 Fuel Consumption Measurement

Since the hi-lo idle test does not give a direct indication of vehicle fuel consumption two methods of quantifying the results of the emissions-oriented maintenance were employed:

1) Cards were issued to persons who either had existing records of fuel consumption or who were interested in comparing fuel consumption before and after adjustment by establishing the "before" condition over a period of a few weeks and then returning to have the carburetor adjustment done. After keeping a record of fuel used and distance travelled for a month or so afterward, the cards were mailed back to the EPS office in Whitehorse for analysis.
2) Some participants whose vehicles exhibited high CO readings were asked if they would agree to having a fuel flowmeter installed in their vehicle whereupon they would take a short trip in the city noting the amount of fuel used. Following the carburetor adjustment, the same trip was taken and the "after" fuel consumption was recorded. In this way, the fuel consumption benefit of the adjustment could be seen immediately.

2.7 Public Relations Materials

Participants in the program were given pamphlets which outlined the factors affecting fuel consumption such as vehicle loading, rolling resistance, driving habits and vehicle condition with a view to highlighting the fuel economy benefits possible with improved vehicle maintenance and minor changes in driving style. The contents of the pamphlet are shown on page 1 of the Appendix A.

A bumper sticker which read "I'm in Tune" was also made available to those participants whose vehicles left the test site properly adjusted.

3 PROGRAM RESULTS

A total of 3512 vehicles were tested over the course of the program.

Table 1 shows the breakdown of the test fleet according to age and annual distance travelled.

TABLE 1 VEHICLE AND VKT DISTRIBUTION FOR WHITEHORSE TEST FLEET

Age	Av. Annual km Travelled	Percent of Total Fleet	Percent of Spec VKT
1	19949	3.5	4.0
2	20361	8.1	9.6
3	18609	10.7	11.7
4	18247	12.2	13.0
5	18101	11.7	12.4
6	16409	10.4	10.0
7	16540	8.8	8.4
8	15439	10.1	9.1
9	14942	6.3	5.7
10	14139	5.2	4.5
11	15650	2.9	2.4
12	15842	2.5	2.2
13	15907	2.6	2.4
14	15964	1.2	1.2
15	14577	1.2	1.0
16	17263	0.5	0.5
17	18540	0.7	0.7
18	13100	0.3	0.3
19	10350	0.5	0.3
20	16000	0.1	0.1
Av.	16312		

As in other programs, the newer vehicles account for the bulk of the annual fleet VKT. Because of the absence of road salt, however, there are more older vehicles in Whitehorse than in a city like Montreal.

3.1 Odometer Distribution

Figure 1 illustrates the breakdown of odometer readings for the test fleet. Over 70% of the fleet had travelled less than 100,000 km, however, there was a significant percentage (8.9%) which had gone more than 150,000 km.

Odometer Reading (km)	Number of Vehicles
0 - 10,000	167
10 - 20,000	220
20 - 30,000	228
30 - 40,000	274
40 - 50,000	277
50 - 60,000	278
60 - 70,000	286
70 - 80,000	292
80 - 99,000	237
90 - 100,000	231
100 - 110,000	202
110,000 +	849

FIGURE 1 ODOMETER DISTRIBUTION

3.2 Size Distribution

Table 2 shows the breakdown of the fleet according to vehicle size.

TABLE 2 VEHICLE AND VKT DISTRIBUTION vs SIZE FOR WHITEHORSE TEST FLEET

Size Code	Vehicle Type	Av. Annual VKT	% of Total Fleet	% of Total VKT
1	Subcompact	13859	3.7	3.0
2	Compact	13786	16.3	13.1
3	Intermediate	15239	12.9	11.4
4	Full Size	16572	12.7	12.4
5	L.D. Truck	18578	39.3	42.8
6	H.D. Truck	19489	15.2	17.3

Interestingly, 54.5% of all vehicles tested were light duty or heavy duty trucks. This is very much different from surveys done in other cities where the number of trucks inspected was very small.

It would appear that many subcompact vehicles were wrongly classified as compacts as evidenced by the fact that while 18.7% of the fleet was made up of Japanese cars which are almost always subcompacts, only 3.7% of the fleet were reported as such. Consequently no distinction should be made between these two groups. Rather, the two combined would likely represent more accurately the small car fleet in the area.

3.3 Emission Results

3.3.1 By Age. Idle emissions are tabulated in Tables 3 to 6 according to age, vehicle size, number of cylinders and manufacturer.

TABLE 3 AVERAGE IDLE CO AND HC BY VEHICLE AGE - BEFORE AND AFTER ADJUSTMENT

		Before Adjustment				After Adjustment		
Age	No.	CO%	HC ppm	% @ Spec	% Adjusted	CO%	HC ppm	% @ Spec
1	122	1.2	230	57.3	24.6	0.8	200	71.3
2	287	1.9	310	41.1	38.0	1.1	250	65.8
3	377	1.9	390	40.6	44.6	1.0	330	69.5
4	430	2.3	430	31.6	61.9	1.2	330	64.7
5	413	2.4	440	31.5	61.3	1.3	330	62.2
6	367	2.8	460	28.1	63.5	1.5	350	50.9
7	311	2.6	420	31.2	66.3	1.4	320	62.0
8	355	2.7	520	29.9	59.4	1.6	410	58.6
9	223	3.4	530	25.6	64.6	1.9	420	50.2
10	182	2.9	580	31.3	60.4	1.9	460	55.0
11	103	3.0	550	36.9	54.3	1.8	450	49.5
12	87	3.0	660	20.7	58.6	1.8	510	52.9
13	91	3.0	640	28.6	57.1	2.0	510	40.7
14	44	3.6	760	20.4	61.4	2.1	670	38.6
15	44	3.5	740	11.4	70.4	2.1	620	34.1
16	19	3.9	760	5.3	80.0	2.1	650	42.0
17	24	3.8	610	8.3	87.5	2.0	530	45.8
18	12	3.4	550	16.7	75.0	2.0	380	50.0
19	19	2.7	600	31.5	79.0	1.6	510	63.1
20	2	6.2	550	0	100.0	1.5	210	100.0
Mean	3512	2.53	460	32.9	58.2	1.4	370	60.5

Table 3 shows that the CO and HC emissions both before and after adjustment were higher for older vehicles than for newer ones but all vehicles, regardless of age, showed a significant reduction in emissions following carburetor adjustment. It should be

TABLE 4 AVERAGE IDLE CO AND HC BY VEHICLE SIZE - BEFORE AND AFTER ADJUSTMENT

		Before Adjustment				After Adjustment		
Vehicle Size	No.	CO%	HC ppm	% @ Spec	% Adjusted	CO%	HC ppm	% @ Spec
Sub Compact	128	2.8	320	53.1	49.2	1.8	260	64.1
Compact	567	2.6	380	51.8	48.4	1.8	310	61.8
Intermediate	449	2.5	500	32.9	54.4	1.4	380	62.4
Full Size	444	2.5	520	25.1	63.1	1.3	420	59.8
L.D. Truck	1370	2.5	490	29.3	60.6	1.4	390	60.2
H.D. Truck	529	2.5	450	22.7	64.6	1.3	340	57.8

TABLE 5 IDLE CO AND HC vs NUMBER OF CYLINDERS

		Before Adjustment				After Adjustment		
No. of Cylinders	No.	CO%	HC ppm	% @ Spec	% Adjusted	CO%	HC ppm	% @ Spec
4	879	2.7	380	58.8	48	1.9	320	62.8
6	554	2.6	480	24.7	65.2	1.3	390	60.8
8	2060	2.5	500	26.5	58.9	1.3	380	59.4

TABLE 6 IDLE EMISSIONS BY MANUFACTURER

		Before Adjustment			After Adjustment			
Manufac-turer	No.	CO%	HC ppm	% @ Spec	% Adjusted	CO%	HC ppm	% @ Spec
GM	1307	2.2	500	32.0	53.0	1.2	400	62.8
Ford	1067	2.7	470	23.9	67.0	1.4	350	55.9
Chrysler	283	2.8	460	25.3	64.5	1.3	360	66.2
AMC	38	3.2	390	28.9	68.4	1.5	330	57.9
Japanese	656	2.7	380	50.6	55.2	1.7	315	63.9
European	115	3.3	510	41.7	33.0	2.8	430	47.0
Other	39	3.1	425	25.6	69.2	1.6	300	56.4

noted that the oldest vehicles in the program which were not designed with emission control in mind were still capable of operating at HC and CO levels almost as low as their newer counterparts.

As in most other programs, the highest incidence of vehicles "at spec" at idle was for 1 to 3 year old models. In absolute terms however, the percentage of these new vehicles at spec is lower than in other surveys where typically 70% of one year old models were found to be running properly. Only 57% of the newest vehicles were properly adjusted in the "as received" condition in Whitehorse.

Four to fourteen year old vehicles were found to be anywhere from 20 to 35% at spec in no definite pattern. The oldest vehicles were least often at spec as expected.

Overall, 32.9% of vehicles inspected were operating at spec prior to adjustment. This is a typical value for such a program; the percentage of vehicles at spec in Montreal (1981) was 33.1%; in Halifax (1979) it was 34.2. After carburetor adjustment, 60.5% of the Whitehorse fleet was operating at spec. This is lower than for other programs and is indicative of a large number of engines requiring more extensive repairs. (Only 58.2% of vehicles were adjusted).

Of note is the fact that the average incoming idle CO% was fairly low at 2.53%. Outgoing CO% was 1.4%. The low incoming CO% value reflects a fleet that is only marginally off spec on the whole. For the Montreal and PEI inspection projects, the incoming coverage CO% was 3.3% and 3.2% respectively. On the other hand, the average outgoing value is higher for the Whitehorse fleet at 1.4% than for the above-mentioned Montreal and PEI groups which were at 1.2% and 1.0% respectively.

3.3.2 **By Vehicle Size.** Average idle CO and HC by vehicle size is shown in Table 4. The small cars were found to be most often at spec even though the absolute average idle CO for these vehicles was slightly higher (2.7%) than for other groups. The allowable CO% limit for the four cylinder engines which generally power such vehicles is much higher, however, than the maximum for six and eight cylinder engines.

After adjustment, the small car class had the highest average idle CO at 1.8% compared to 1.3-1.4% for the other groups. Approximately sixty percent of all vehicle types were operating at spec following adjustment.

3.3.3 **By Engine Size.** Looking at idle CO by number of cylinders in Table 5, the incoming idle CO% was in the area of 2.6% for all engine sizes. Six cylinders engines were least often at spec in the before condition with only 24.7% adjusted properly.

Eight cylinder engines were only slightly better with 26.5% at spec before adjustment. Four cylinder engines, because the specification limit is higher, were the best performers with 52.8% at spec.

After adjustment, all engine sizes were approximately 60% at spec.

3.3.4 By Manufacturer. According to manufacturer, as shown in Table 6, Japanese vehicles were the best performers emission-wise with 50.6% of vehicles not requiring adjustment. European cars were next with 41.7% followed by GM at 32% and the remaining manufacturers around 25%.

This is consistent with the findings of other studies in which Japanese and European vehicles tend to be within spec most often. This is due to the fact that these vehicles are almost exclusively powered by four cylinder engines which, as mentioned before, are allowed higher CO levels. Some newer GM vehicles are equipped with non-adjustable carburetors which are preset at the factory. This tends to improve the performance of GM models in such inspection programs relative to other makes.

3.4 2500 rpm Emissions

Emissions are measured at 2500 rpm as an indication of carburetor main circuit performance. The idle jet has only a small influence on the air/fuel ratio at this point and, as a result, if a vehicle is found to be over the recommended limit for CO, little can be done aside from informing the owner of an improper float level or similar internal problem in the carburetor. High HC emissions at 2500 rpm are usually the result of a poor ignition system or internal engine problems.

3.4.1 Breakdown by Age. Looking at Table 7, it may be seen that 2500 rpm emissions increase with vehicle age. For CO, this is due to the increased instance of carburetor malfunctions among the older vehicles and also as a result of the original jet size selection. Late model vehicles have been designed to run lean for best fuel economy. Older vehicles were often designed with power in mind and thus were calibrated to run richer. Hydrocarbon emissions increase with age and mileage as piston rings and valves wear and ignition system performance deteriorates.

3.4.2 Breakdown by Engine Size. As seen in Table 8, very few vehicles left the test site "at spec", even after adjustment. The V-8's were the best performers in this category with 46.4% of vehicles coming in at spec. Curiously, fewer of the four cylinder engines were at spec after adjustment than before, probably because the leaner overall mixture,

TABLE 7 2500 RPM EMISSIONS AS A FUNCTION OF AGE - BEFORE AND AFTER ADJUSTMENT

		Before Adjustment			After Adjustment		
Age	No.	CO%	HC ppm	% @ Spec	CO%	HC ppm	% @ Spec
1	122	1.2	160	45.0	1.1	150	44.2
2	287	1.2	180	47.4	1.1	170	49.8
3	377	1.1	210	51.1	1.0	190	54.6
4	430	1.1	220	52.8	1.0	200	57.2
5	413	1.1	230	56.9	1.0	210	60.3
6	367	1.7	260	38.1	1.5	240	48.0
7	311	1.6	250	42.7	1.4	230	48.6
8	355	2.0	360	41.7	1.8	340	41.9
9	223	2.3	400	34.0	2.1	360	36.8
10	182	2.0	550	36.8	1.9	510	41.2
11	103	2.1	390	42.7	1.8	370	43.7
12	87	1.8	550	41.3	1.6	515	42.5
13	91	2.4	600	24.1	2.3	565	35.2
14	44	2.7	740	15.9	2.5	740	25.0
15	44	2.6	460	29.5	2.4	450	27.2
16	19	2.3	900	21.0	2.2	860	21.0
17	24	2.8	700	16.7	2.6	670	20.8
18	12	3.3	450	25.0	3.3	400	25.0
19	19	3.2	690	15.7	3.3	680	21.0
20	2	8.0	700	0	2.9	350	50.0

TABLE 8 2500 RPM EMISSIONS BY NUMBER OF CYLINDERS

Number of Cylinders		Before Adjustment			After Adjustment
	No.	CO%	HC ppm	% @ Spec	% @ Spec
4	879	2.27	255	42.9	34.4
6	554	1.64	370	42.8	50.0
8	2060	1.31	320	46.4	53.0

while sufficient to meet the CO limit, was causing high HC emissions due to intermittent misfire.

Research has indicated that up to 40% of the fuel used by a 4 cyl. engine in a low speed cycle passes through the idle circuit(3). Therefore, if this idle fuel flow were reduced sufficiently, the main circuit air-fuel ratio would be affected in the lean direction with an attendant potential for lean misfire and therefore, high HC emissions.

3.4.3 Breakdown by Manufacturer. By manufacturer, GM and AMC were the best performers at 2500 rpm with 52.7 and 50.0 percent of vehicles at spec before adjustment improving to 56.3 and 63.2 percent after adjustment.

TABLE 9 2500 RPM EMISSIONS BY MANUFACTURER - BEFORE AND AFTER ADJUSTMENT

Manufacturer	No.	Before Adjustment			After Adjustment		
		CO%	HC ppm	% @ Spec	CO%	HC ppm	% @ Spec
GM	1307	1.3	300	52.7	1.2	275	56.3
Ford	1067	1.4	345	39.0	1.2	320	46.0
Chrysler	283	1.8	400	37.4	1.5	380	47.0
AMC	38	1.4	305	50	1.1	290	63.2
Japanese	656	2.2	240	44.5	2.1	220	35.8
European	115	2.6	320	36.5	2.4	300	35.1

Ford and Chrysler products went from 39.0 and 37.4 percent before to 46.0 and 47.0 percent after.

Japanese and European vehicles both got worse at 2500 rpm after adjustment. Before and after values for Japanese cars were 44.5 and 35.8 for European cars they were 35.6 and 35.1 respectively.

3.5 EGR Valve Operation

Tables 10 and 11 illustrate the results of the EGR valve function check by engine size and manufacturer.

Four cylinder engines were least often equipped with EGR valves (only 39.5% of all four cylinder engines) but had the highest percentage of those which were operational (79%).

TABLE 10 EGR VALUE OPERATION BY NUMBER OF CYLINDERS

Number of Cylinders	Total No .	Number Equipped	% Operating
4	879	347	79.0
6	554	267	75.3
8	2060	942	65.0
Overall	3493	1556	69.9

TABLE 11 EGR VALUE EQUIPPED/OPERATIONAL BY MANUFACTURER

Manufacturer	No.	Equipped	% Operating
GM	1307	583	72.4
Ford	1067	588	67.5
Chrysler	283	95	59.0
AMC	38	23	47.8
Japanese	656	231	76.6
European	115	12	50.0

Forty-eight percent of the six cylinder engines inspected had EGR valves of which 75.3 percent were working.

Of the eight cylinder engines, 45.7% were equipped with EGR but only 65.0% were in working order.

This represents an extremely high tampering failure rate, especially with the eight cylinder engines.

3.6 Fuel-Switching

Fuel-switching or misfueling are terms used to describe the practice of using leaded fuel in a vehicle equipped with a catalytic converter. Lead causes the catalyst to become inoperative in a very short period resulting in increases of hydrocarbon and carbon monoxide emissions by a factor of 3 or 4.

Regular unleaded fuel was found to account for only 13.3% of total fuel sales in Whitehorse according to this survey. In Ontario during the same period, unleaded fuels accounted for almost 50% of total sales. Given that the fleet breakdown by age was

similar in Whitehorse to that in other parts of Canada, it must be concluded that a good deal of misfueling is occuring there.

This is probably due in part to general non-acceptance of catalytic converters by the populace and to the high price of fuel in the area. The combination of a maltuned and misfueled vehicle results in emissions levels which are very high.

Fuel Use:	% of Sales
Regular Leaded	85.4
Regular Unleaded	13.7
Premium Unleaded	0.3
Diesel	0.3

3.7 Tire Pressure Check

Low tire pressure is a condition common to most vehicles on the road and is a leading contributor to excess fuel consumption. While the emission check was being performed tire pressure were checked and the owner was notified of any low readings. 73.1% of all vehicles checked had at least one underinflated tire.

3.8 Fuel Consumption Data from Mailback Program

About 500 fuel consumption record cards were sent to Whitehorse residents in May of 1981. Only four valid responses were ever obtained; a very poor result. The few data points obtained are shown below:

	Idle CO		Fuel Consumption l/100 km		
Vehicle Type	Before	After	Before	After	% Diff.
'78 Ford LTD	3.4	1.3	26.3	22.2	15%
'69 GMC Truck	6.5	1.0	19.5	15.7	19%
'74 Valiant	N/A	N/A	14.0	13.3	6%
'78 Dodge Truck	N/A	N/A	18.9	14.0	26%

The measured improvements in fuel consumption are on the whole quite large and most likely reflect greater awareness of fuel-saving during practices in the part of the owner following his visit to the "Test and Tune" site.

3.9 Fuel Flowmeter Data

Some participants were given the opportunity to measure short term fuel consumption before and after the carburetor adjustment by having a Fluidyne 1250 fuel flowmeter installed in their vehicle. After taking a short trip through the city and noting the amount of fuel consumed, the carburetor adjustment was done and the same trip was repeated. A percent difference in fuel consumption was calculated from the difference in the amount of fuel consumed.

A total of 21 vehicles underwent such testing with measured fuel savings of 2% to 16%. The mean savings for the 21 vehicles was 5.88% with a standard deviation of 3.69.

For many of these observations, only the before and after fuel volumes were available, making it difficult to identify the source of the fuel saving. (Remember that fuel-saving driving tips might have influenced the result of the "after" trip).

The following table shows detailed information on eight of the flowmeter tests. Of interest in the table are the difference in before and after idle CO%, the time required to complete the before and after trip (which gives an indication of average speed) and the difference in fuel consumed.

With two exceptions, average trip speed was held relatively constant and the measured percent savings ranged from a low of 2% to a high of 11.6%.

The average savings for the group was 7.7%.

Vehicle	Idle CO% before	after	Distance	Δcc's	Time	Δt %	%Δ F.C.	ΔMPG
'69 GM LTD 6-cyl	5.6	1.1	3.31 mi	-16	441 520	79 s +18%	-2.7%	0.5
'76 GM MDT 8-cyl.	5.0	1.0	2.35 mi	-95	317 313	-	-11.6%	1.7
'80 Ford MDT 8-cyl.	2.1	0.4	14.5 km	-68	956 1016	60 s +6.3%	-6.3%	0.4
'78 GM LDT 8-cyl.	0.3	0.6	-	-110	456 456	0	-11.4%	1.7
'80 Ford LDT 8-cyl.	7.2	0.6	6 km	-68	442.2 422	20 s -4.5%	-5.6%	0.7
'77 GM LDT 8-cyl.	4.0	0.9	9.3	-120	1050 941	-109 -10.9%	-5.0%	1.0
'79 GM HDT 8-cyl.	6.0	0.6	5.3 km	-41 cc	1082 1041	41 -4%	-3.8%	0.6
'78 Ford LDT 8-cyl.	2.5	0.8	3.31 mi	-70 cc	464 464	-	-7.4%	1.3
							-7.7%	Av. 1.0

4 CONCLUSIONS BASED ON "TEST AND TUNE" RESULTS

1. The vehicle fleet tested in Whitehorse was very much different from that in other Canadian cities in that the majority of vehicles tested were either light or heavy duty trucks.
2. A significant reduction in tailpipe CO emissions was brought about by proper carburetor adjustment. However, the magnitude of the maladjustment in most cases was lower than expected.
3. Only 33% of the fleet was operating at spec prior to adjustment. A simple carburetor adjustment increased this percentage to 60.5% for the outgoing fleet.
4. Measured HC concentrations were higher than would be expected for all vehicle types of all ages. As high HC emissions may be caused by a number of factors other than excessively rich idle fuel/air mixture, the adjustment did not always bring HC emissions into spec. As a result the after adjustment "at spec" figure is fairly low.
5. The age distribution of vehicles in Whitehorse is relatively uniform for the first ten years without a significant trend to higher annual VKT for new cars such as is seen in other cities. Beyond ten years of age the number of vehicles decreases rapidly as does annual VKT.
6. Smaller vehicles (normally with 4 cylinder engines) were found to most often meet the required emission specifications at idle. This was also true of the percentage of EGR valves working as a fraction of vehicles so equipped.
7. 2500 rpm emissions were high on the average and were relatively unaffected by the idle mixture adjustment.
8. Misfueling would appear to be a problem in the area, and as a result, few catalyst-equipped cars would be operating at their potential for low emissions.
9. The mailback program for fuel consumption data was poorly received (less than 1% response rate). Of four valid responses received, the average noted improvement in fuel consumption was 16.5%.
10. Short term tests with a Fluidyne 1250 flowmeter produced more data, indicating an average 5.88% reduction in fuel consumption for 21 vehicles as a result of "Test and Tune".

REFERENCES

1. Gullon, A.C., Exhaust Emission Capabilities of Showroom Cars, SAE 780081.

2. Environment Canada, Air Pollution Control Directorate, Control of Excessive Emissions and Fuel Consumption by In-Use Motor Vehicles Report EPS 3-AP-81-2.

3. Coyles, David, Idle Circuit Fuel Flow. Mobile Sources Division Report 83-02.

AIR QUALITY ANALYSIS

1 INTRODUCTION

Laboratory testing of in-use motor vehicles has shown that improper idle mixture adjustment can cause a vehicle's CO emissions to increase by 50% over the manufacturer's design level. CO emissions from gasoline combustion engines are strictly a function of the air-fuel ratio of the combustion process. The point at which the amounts of air and fuel are perfectly balanced for complete combustion is called the stoichiometric point. At this point, CO emissions are very low. If the amount of fuel is increased, the mixture becomes rich and CO emissions increase drastically. Naturally, excessive richness in the idle circuit will have the effect of increasing CO emissions for the idle and low speed cruise conditions. By returning the idle adjustment to its leanest possible point, the fuel/air ratio may approach the ratio or leaner with correspondingly low emissions.

The impact of an inspection/maintenance program has already been partially analysed, now the question of the impact of such a program on air quality in the Whitehorse region must be examined.

The objective of this section of the report is to analyse information on ambient CO pollution as monitored by the NAPS station in Whitehorse both before and after the inspection/maintenance project. For this purpose, the air quality data as measured by the air quality monitoring station are summarized and, based on both statistical and other forms of analysis, the changes in air pollution levels of CO are outlined. Subsequently, the CO data are compared with the gasoline sales before and after the "Test and Tune" project.

2 DATA SOURCES

2.1 The main daily Carbon monoxide level for Whitehorse was obtained from the NAPS continuous monitoring station No. 09001C (C = commercial) located in the Whitehorse Federal Building (see Figures 1 and 2), Appendix A. This monitoring station is located close to a major traffic artery and to the north of downtown Whitehorse. (See Figures 1 and 2, Appendix A). Constant monitoring was available only for a 5 month period (November, December, January, February and March) of 78/79, 79/80, 80/81 and 81/82. This data is presented in Tables 1 to 10 of Appendix A. The tables include average daily CO concentration in parts per million, minimum daily temperature in °C, average daily wind speed in km/h average prevailing wind direction and calculated weather factors, C_1 (see subsequent paragraphs).

2.2 Meteorological data for ambient temperature, wind speed and direction were obtained from the "Monthly Meteorological Summary" reports published by Environment Canada for Whitehorse. It should be noted that these figures reflect measurements taken at the Whitehorse Airport which is located on a plateau about 30 metres above the city and about 1 kilometre to the west. The winds at this point may be weaker than those in the city due to the peculiar topography of the area, but because of proximity of location, they were assumed to be proportional.

2.3 Data on gasoline sales, motor vehicle registrations, the number of vehicles entering Yukon from Alaska, the population of Whitehorse and of the Yukon and retail trade in the Yukon were taken from Reference 5, and are summarized in Table 5. This information was needed to develop the relationship between gasoline sales and other factors which affect gasoline demand.

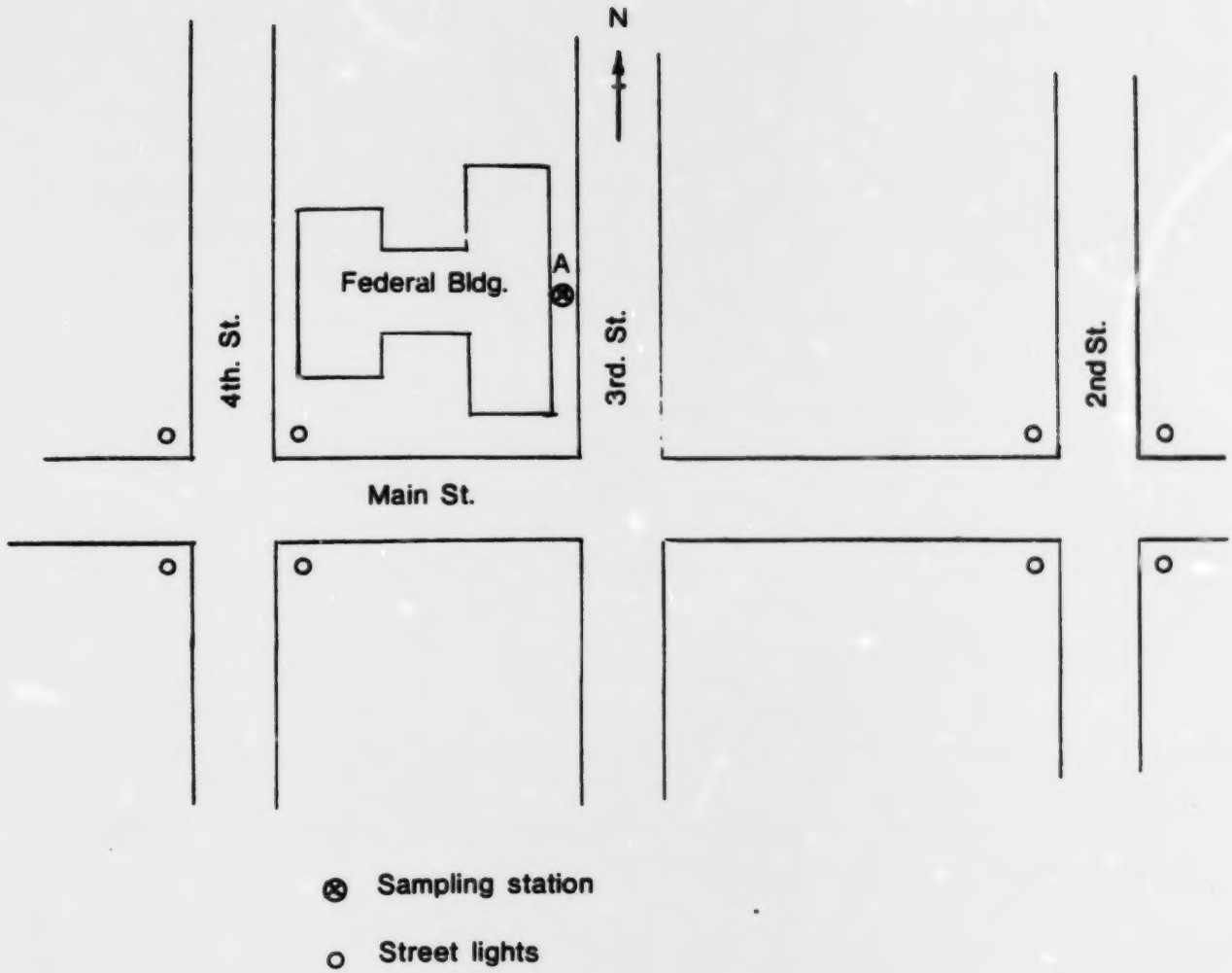


Figure 2. Location of the Federal building and sampling station in Whitehorse

LAKE LABERGE
Upper Laberge
Laberge
Creek
Crouch Creek
Whitehorse
Schwatka Lake
Cowley Creek
Cowley Lakes
McConnell Lake
Robinson
GOLDEN HORN
MT. GRANGER
DOUBLE MTN.
Fugdale
Fish Lake
Hunnewell
Frank
Jackson
Lucas
Mt. Ray
Mt. Sumanik
Mt. Lorne
RIVER
RANGE

3 DATA ANALYSIS

3.1 Predicting Air Quality Trends

It is important to note that a pollutant such as CO is nonreactive and as long as emission level changes do not alter the distribution of emissions, then the resulting change in the air quality level will be directly proportional to the magnitude of the source emission change. This theory has been widely used to estimate source reductions required to meet ambient air quality standards for CO control.

Meteorological effects, however, cannot be everlooked when explaining discrepencies in ambient pollutant concentration. Such a complexity of variables is involved in the diffusion of the pollutant that no rigorous mathematical solution has yet been developed. It has been found, however, that a statistical representation of the problem is often statisfactory if care is taken in choosing the parameters(1).

Atmospheric dispersion of pollutants depends on wind speed and direction, and the stability of the atmosphere (i.e. inversion). The transport and dispersion of atmospheric pollution are, in turn, affected by the extent and configuration of irregularities in the terrain such as hills, valleys, shorelines, and man-made features.

The seasonal and daily weather fluctuations also affect the emission of pollutants which causes significant variations in air quality at a particular monitoring site. Atmospheric concentrations of motor vehicle related pollutants, particularly CO, follow seasonal patterns, which result primarily from the effect of ambient temperature on motor vehicle emissions(2).

Since the concentration of atmospheric CO is inversely proportional to the wind speed(1) and since CO emissions from automobiles are inversely proportional to the ambient (soaking) temperature(2) a simplified "weather correction factor" C_1 can be developed for the regressions of the ambient CO concentration in Whitehorse:

$$C_1 = T \times W \times 10^{-3}$$

where

T = absolute minimum daily temperature, °K

W = average daily wind speed, km/h

The following first order least squares regression model was used to establish trendlines of CO concentration for each 5 month period in Whitehorse:

$$\ln(y) = a_0 + a_1 C_1$$

where

ln = natural logarithmic function

y = CO concentration, ppm

C_1 = weather correction factor, $\frac{°K \times km}{h} \times 10^{-3}$

After the data had been reduced to trendlines interpolated values of the dependent variable were then obtained by conversion from the logarithms.

Figure 3 on the following page is a graphic presentation of the daily average CO concentration in Whitehorse for a 4 year period. As can be seen from the figure, the CO concentration increases in 78/79 and 80/81, and then rapidly decreases in 1981/82 following the "test and tune" program.

The relation between air quality and the "weather factor", C_1 is well defined, and there appears to be no systematic difference between this relation from 1978/1979 to 1981/82. Apparently the linear model for air quality is quite adequate. In other words, information wind speed and ambient temperature are sufficient to predict ambient air pollution in Whitehorse.

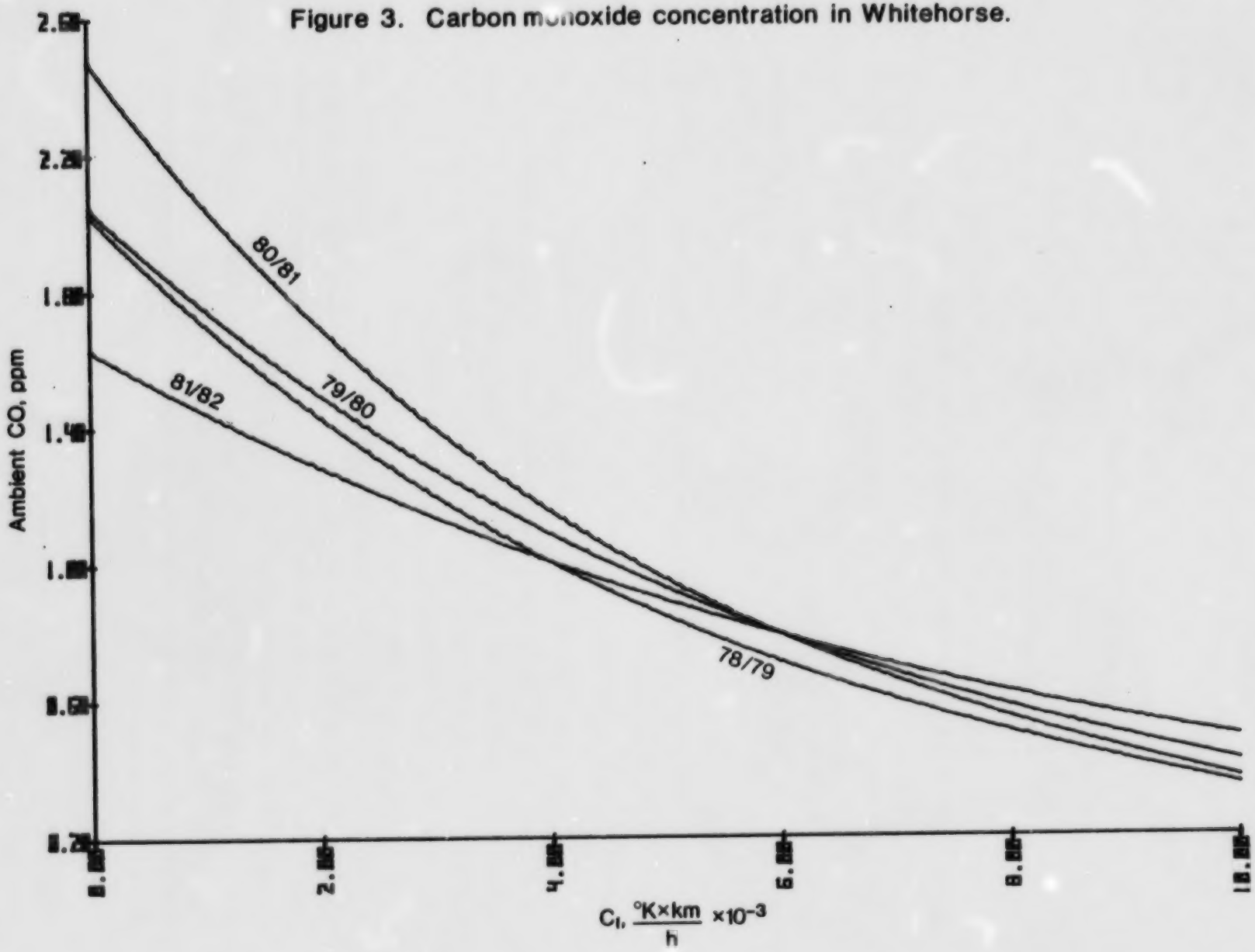
3.2 Windspeed Correction

Due to the fact that there is only one monitoring station in the city, in order to reinforce our confidence in the regression lines, it was necessary to examine other factors which could have an effect on the CO concentration monitored at the Federal Building. One of the most important factors is wind direction, because the station is located to the north of a main traffic artery in the city core (see Figure 2).

Figure 4 on page 29 shows the general location of Whitehorse and the 100 metre contour lines relative to the river valley. It is seen that the valley is narrow and the slopes steep, leading to typical wind directions along the north-south axis of the valley. The annual occurrence of westerly or easterly winds in Whitehorse is reported to be negligible and therefore should not be taken into account.

The daily average wind direction, Tables 1-10 at the end of this section, shows that the most frequent winds at the Whitehorse Airport are from the north and south. This average daily wind direction occurences for 4 analysed 5 month periods are given in Table 1 below on page 30:

Figure 3. Carbon monoxide concentration in Whitehorse.



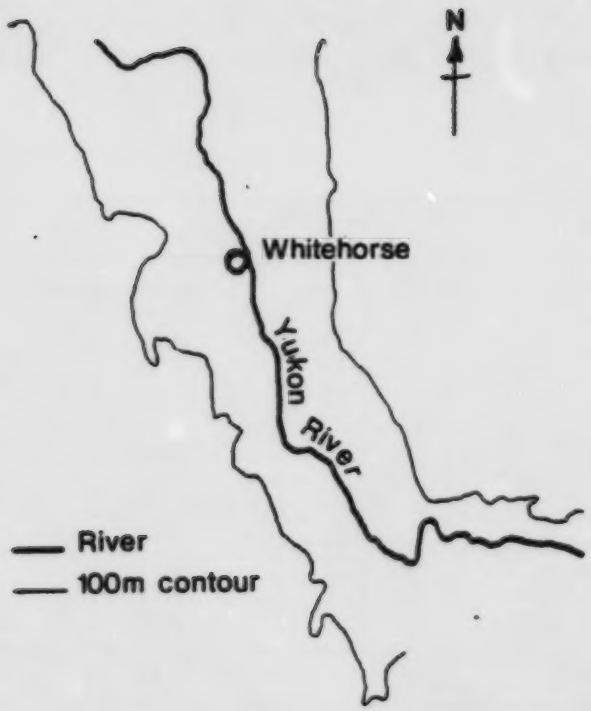


Figure 4. General location of Whitehorse.

TABLE 1

	78/79	79/80	80/81	81/82
Northerly, %	36	40	29	47
Southerly, %	64	60	71	53

As can be seen from the table, there are substantial differences in wind direction occurences between the periods. To check if wind direction has an effect on CO concentration at the monitoring station, a first order least squares regression was performed to establish trendlines of CO concentration for each 5 month period for northerly and southerly wind direction respectively. The results of the regression are summarised in Table 2 and graphically presented in Figure 5 on page 31.

TABLE 2

	78/79			79/80			80/81			81/82		
C_1	N	S	S/N	N	S	S/N	N	S	S/N	N	S	S/N
0	1.90	2.32	1.22	1.78	2.20	1.24	2.31	3.60	1.56	1.56	2.43	1.56
1	1.53	1.91	1.25	1.41	1.88	1.33	1.80	2.84	1.58	1.28	2.05	1.60
2	1.24	1.58	1.27	1.11	1.60	1.44	1.40	2.24	1.60	1.04	1.72	1.65
3	1.00	1.30	1.30	0.88	1.36	1.55	1.09	1.77	1.62	0.86	1.45	1.69
4	0.80	1.07	1.34	0.70	1.16	1.66	0.85	1.40	1.65	0.70	1.22	1.74
5	0.65	0.88	1.35	0.55	0.99	1.80	0.66	1.10	1.67	0.57	1.03	1.81
6	0.52	0.73	1.40	0.44	0.85	1.93	0.52	0.87	1.67	0.47	0.87	1.85
7	0.42	0.60	1.43	0.34	0.72	2.12	0.40	0.69	1.73	0.38	0.73	1.92
8	0.34	0.49	1.44	0.27	0.62	2.30	0.31	0.54	1.74	0.31	0.61	1.97
9	0.27	0.41	1.52	0.22	0.53	2.41	0.24	0.43	1.79	0.26	0.52	2.00
10	0.22	0.33	1.50	0.17	0.45	2.65	0.19	0.34	1.79	0.21	0.44	2.10
Average S/N			1.37			1.86			1.67			1.81

As can be seen, southerly winds cause consistantly higher CO concentrations at the site. The reason for this can be explained by the location of the monitoring station.

These differences in CO concentration with wind direction are quite substantial and should be taken into account for air quality trend calculations.

To correct for wind direction, all CO concentration data taken when winds were from the north were multiplied by the average correction factor C_2 where:

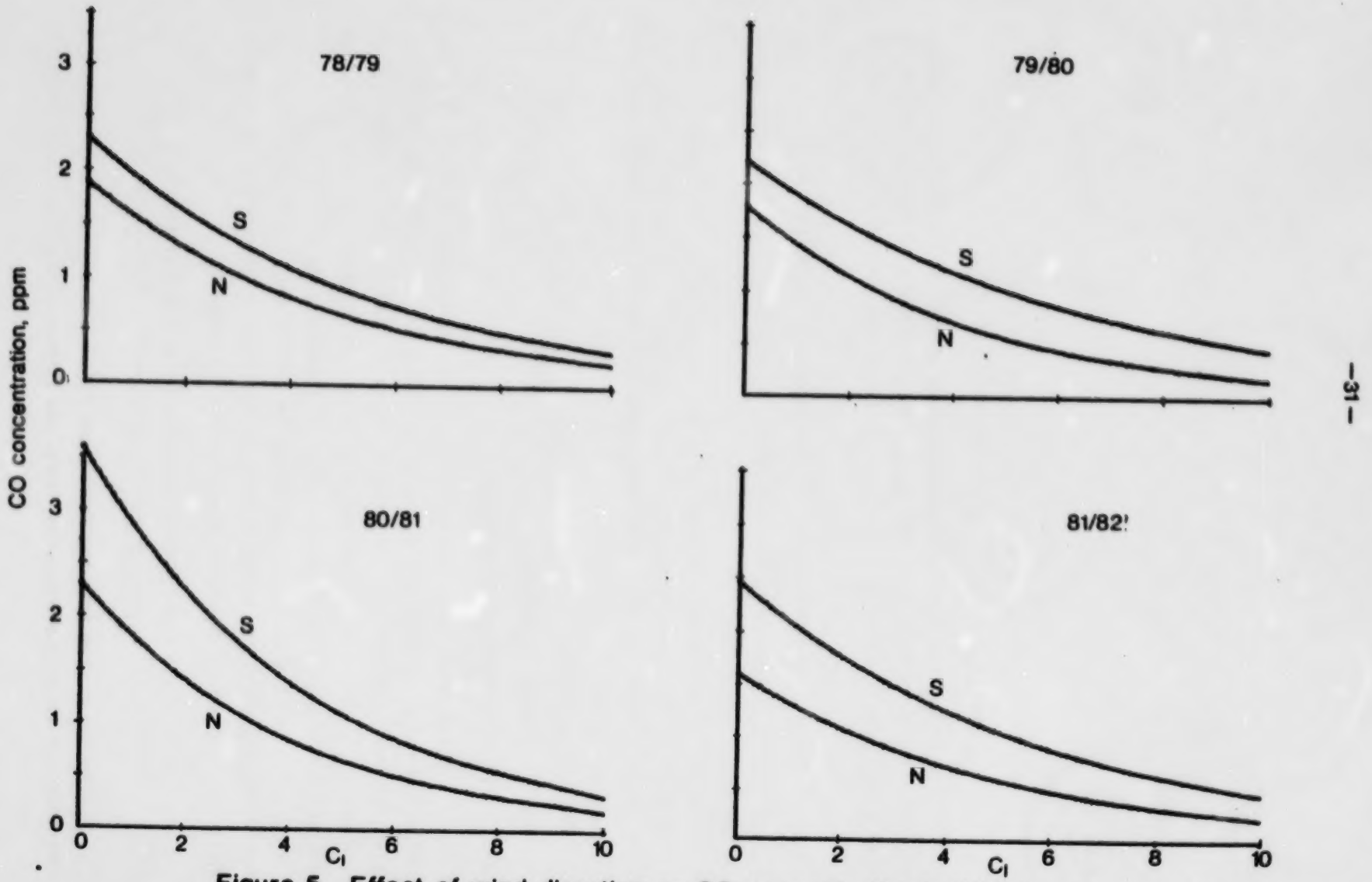


Figure 5. Effect of wind direction on CO concentration in Whitehorse.

$$C_2 = \frac{S}{N}$$

where

C_2 = correction factor, see Table 2
S = CO concentration during southerly winds, ppm
N = CO concentration during northerly winds, ppm

Again the first order least squares regression was used to establish trendlines of corrected CO concentration for each 5 month period. The results of the regression are shown in Figures 6a, b, c and d, in Table 3 (page 38), and also plotted in Figure 7 on page 37.

The following conclusions can be drawn from the Figure 7:

1) Air quality improvising as weather factor C_1 increases (i.e. higher wind speeds) because of better dispersion;
2) Average CO concentration in Whitehorse rose during the 5 month measuring period in 79/78 and 80/81; prior to the "Test and Tune" project.
3) CO concentration diminishes as wind speeds increase because the occurence of inversions is less.
4) The CO concentration for the 5 month period of 81/82 after the "Test and Tune" program dropped significantly.

3.3 Effect of "Test and Tune" Program

In order to estimate the real drop in CO concentration after the "test and tune" program, i.e. in the 5 month period of 81/82, a linear regression of natural logaorithms was performed for each weather factor C_1 (see columns in Table 3). The estimated CO concentration for the period of "81/82 w/o program" was then calculated from the regression, and is given also in Table 3, and plotted in Figure 7.

The last line in Table 3 also shows the percent drop in CO concentration in Whitehorse compared to the predicted trend of concentration increase w/o the "test and tune" program, which was calculated using the following formula:

$$\% \text{ drop} = \frac{\text{CO ppm w/o program - CO ppm with program}}{\text{CO ppm w/o program}} \times 100$$

As can be seen from the Table 3 and Figure 7, during calm days (C_1=0), CO concentration in Whitehorse dropped by 34.4%. As a result of "Test and Tune" program.

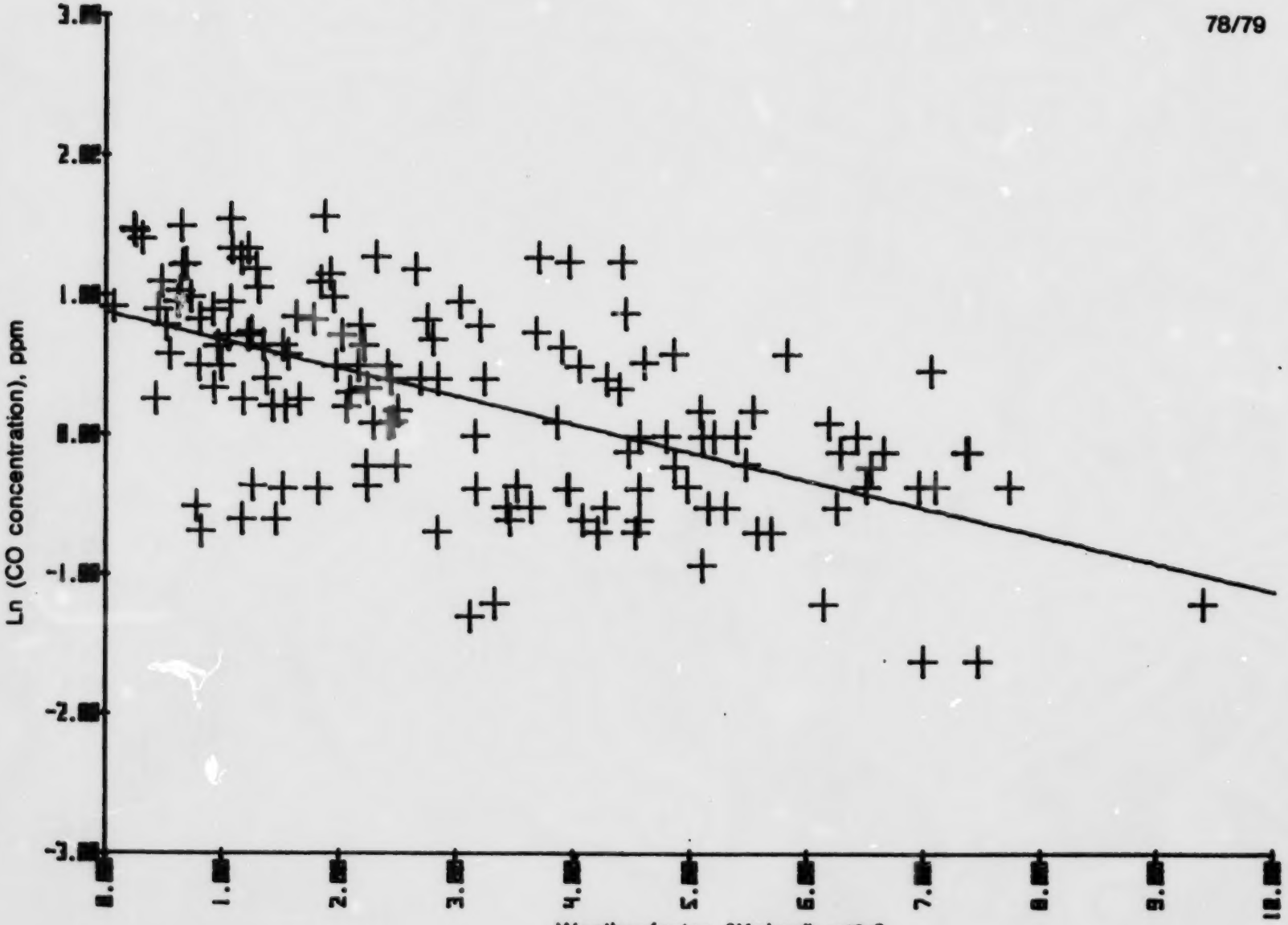


Figure 6a.

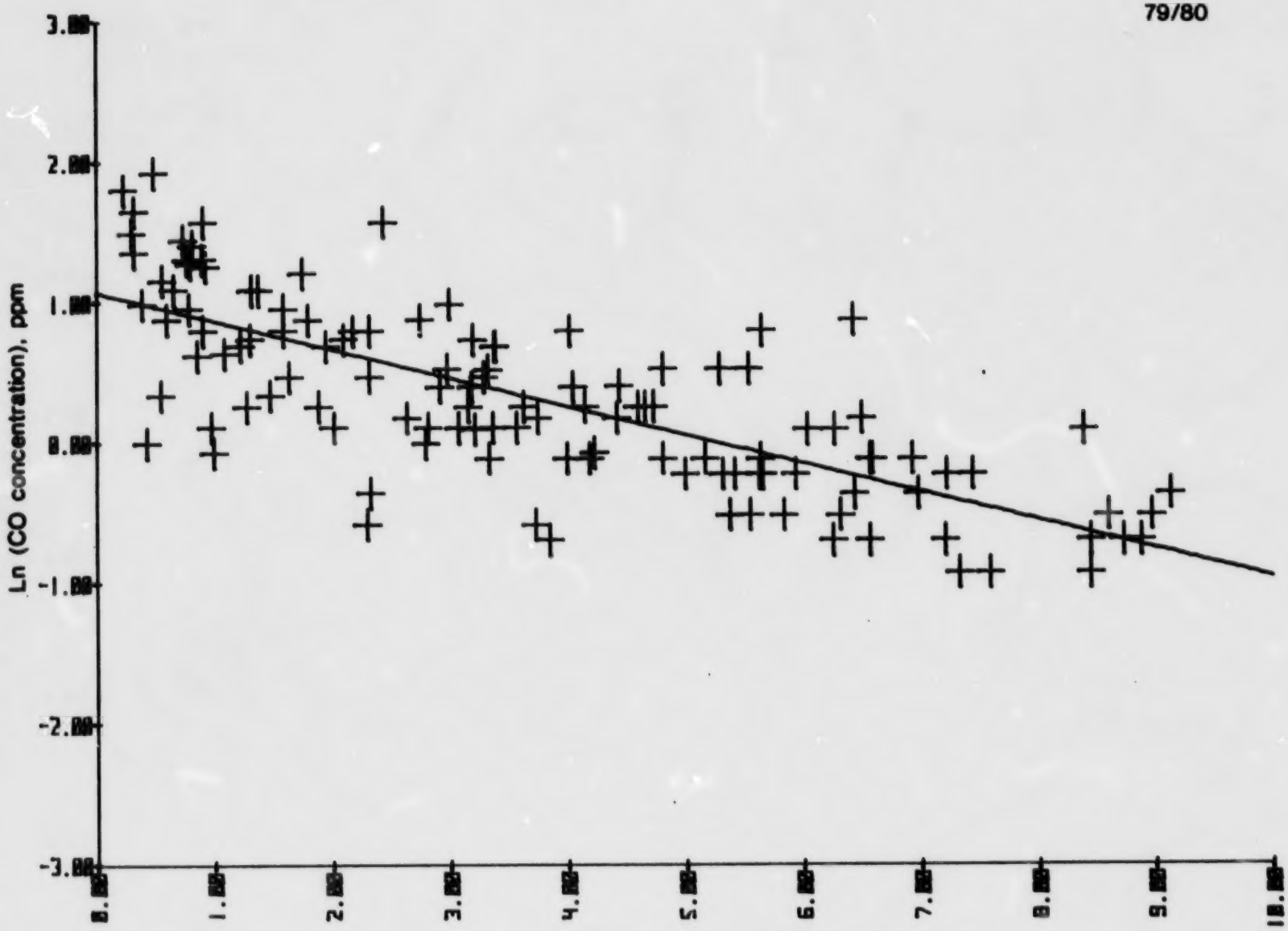

3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
Ln (CO concentration), ppm
0.
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
Weather factor,°K×km/h ×10⁻³

Figure 6b.

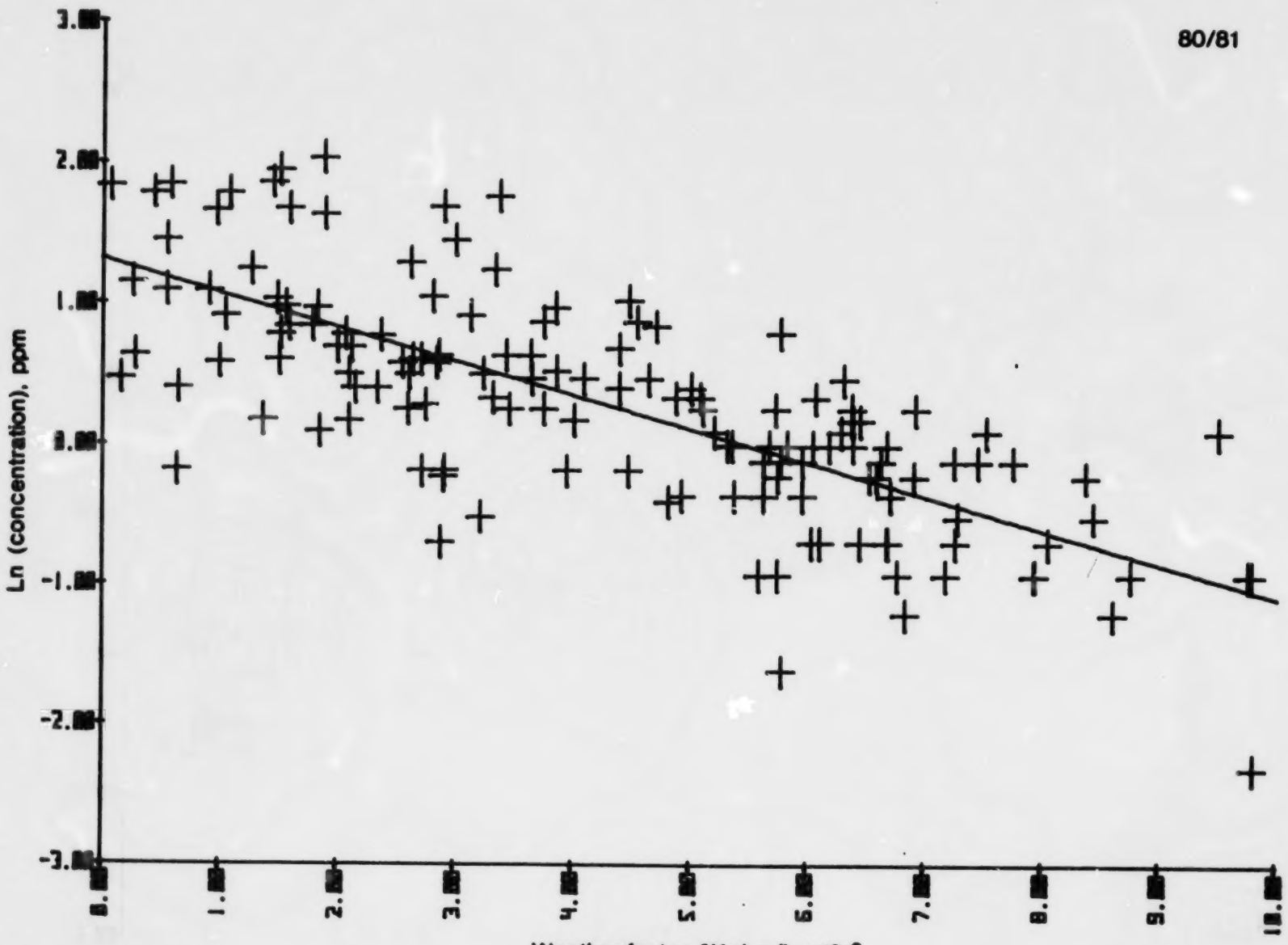

3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
Ln (concentration), ppm
0.
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
Weather factor °K×km/h ×10⁻³

Figure 6c.

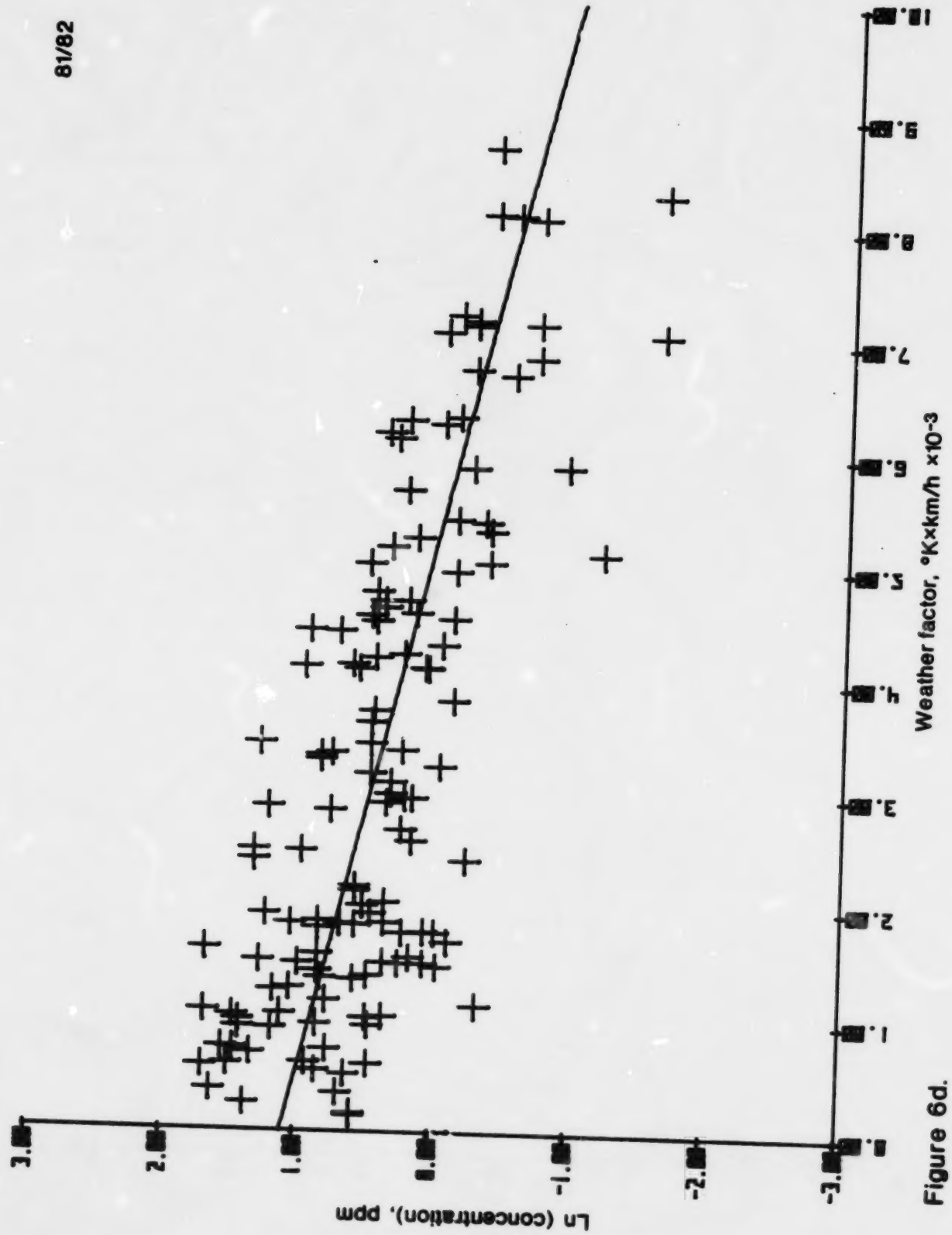


Figure 6d.

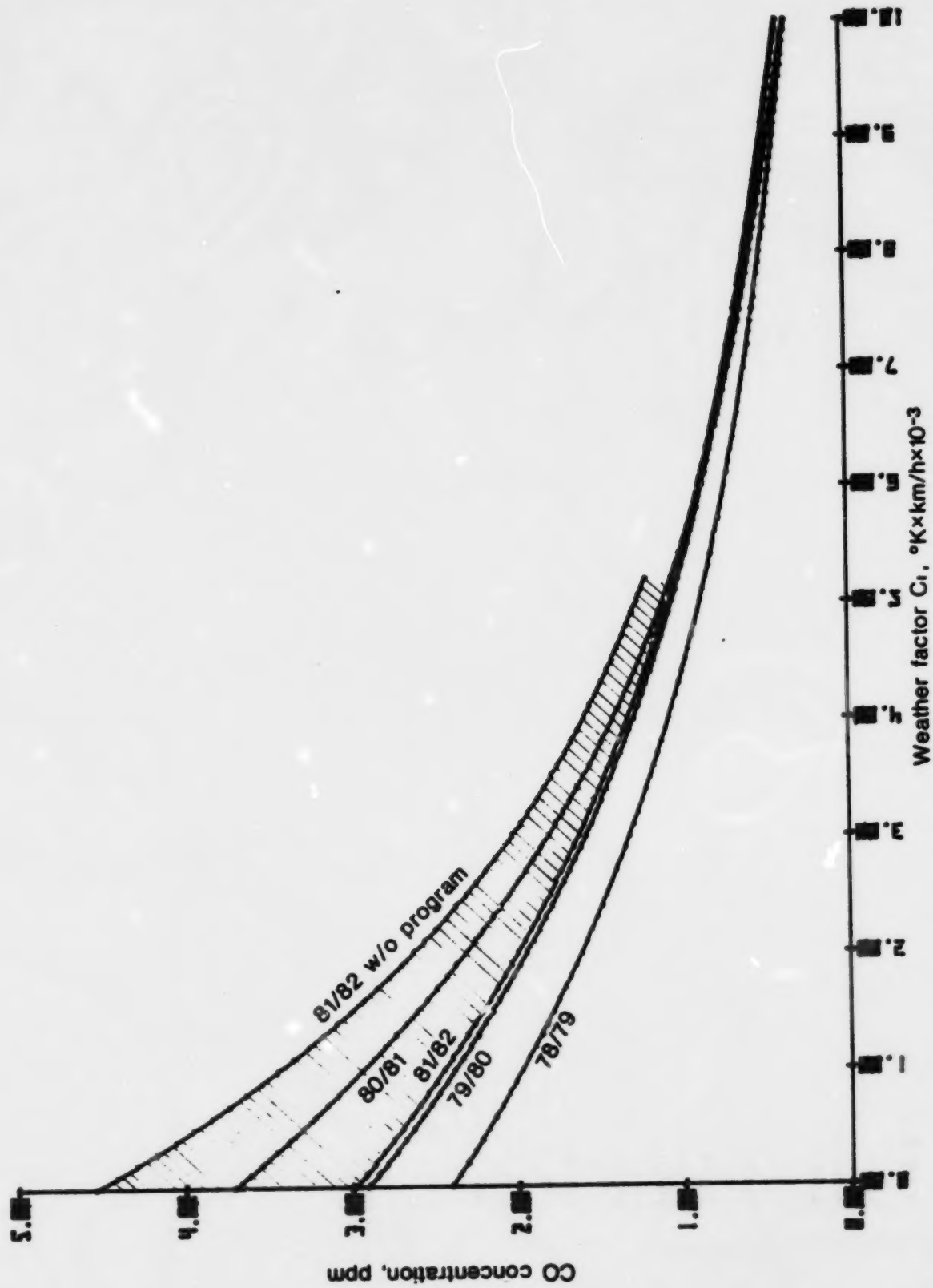


Figure 7. Corrected CO concentration in Whitehorse for each 5 month period.

TABLE 3

Weather factor C_1	0	1	2	3	4	5	6	7	8	9	10	Corr. coeff. R
Period	CO, ppm											
78/79	2.42	1.97	1.61	1.32	1.08	0.89	0.73	0.60	0.49	0.40	0.33	-0.58
79/80	2.91	2.38	1.94	1.59	1.29	1.06	0.86	0.71	0.58	0.47	0.38	-0.75
80/81	3.72	2.93	2.30	1.81	1.43	1.12	0.88	0.69	0.55	0.43	0.34	-0.74
81/82 with program	2.99	2.44	1.99	1.63	1.33	1.09	0.89	0.72	0.59	0.48	0.39	-0.70
81/82 w/o program	4.56	3.39	2.64	2.06	1.62	1.25	-	-	-	-	-	-
Corr. coeff. R	1.00	0.99	1.00	1.00	0.99	0.93	-	-	-	-	-	-
CO% drop	34.4	28.0	24.6	20.9	17.9	12.8	-	-	-	-	-	-

Calm days are the most reliable for this kind of comparison, because wind can introduce some uncertainty, particularly in a geographic area like Whitehorse. In figure 7 and Table 3, the periods before and after the "test and tune" program are compared up to C_1=5.

It should be also noted, that in all cases of regression, correlation coefficients R are high and therefore the degree of association between the data sets is significant, (see Table 3).

3.4 Relationship Between Fuel Consumption and CO Emissions

To relate the effect of changes in fuel consumption (fuel sales) in Whitehorse to changes in atmospheric CO concentration, it is necessary to know the relationship between fuel consumption and the CO emissions of motor vehicles.

Because these data are available only for the standard FTP testing temperature of 20°C to 30°C, it was assumed that, even at lower soaking temperatures, the relationship between fuel consumption and idle CO% would be the same.

Fuel consumption and CO emission data on 138 inspection/maintenance vehicles are given in Table 4 below.

TABLE 4

	No. of cars	Model year	CO improvement %	Fuel consump. improvement %	CO impr. % / Consum. imp. %
Reference 3	94	1975	49	5	9.80
Reference 4	44	1977	66	9	7.33
Reference 6	2000	various	50	5	10.0
	$\frac{2000 \times 10 + 44 \times 7.33 + 94 \times 9.8}{2138}$				9.94

The average increase/decrease of CO emission for each percentage point of increase/decrease of fuel consumption was found to be 9.94, as in Table 4. This relationship between CO emissions and fuel consumption was used to estimate the effect of measured changes in overall fuel sales in Whitehorse on CO emissions.

4 ANALYSIS OF WHITEHORSE FUEL SALES DATA

Table 5 is a summary of fuel sales and all supporting data gathered[5] for analysis of the "Test and Tune" program. The data represents 5 months of statistics for Whitehorse and the Yukon. This matches the previously-discussed 5 month statistics for air quality and meteorological data.

TABLE 5 FIVE MONTHS STATISTICS - WHITEHORSE AND THE YUKON[2]

	77/78	78/79	79/80	80/81	81/82	r
Whitehorse gas sales, L x 10^3	7475 (6535)	6874	7106	7400	7397	1.00
Yukon gas sales, L x 10^3	15022	15927	15580	17246	16998	0.87
Whitehorse population	15617	16618	16843	17354	17789	0.97
Yukon population	23826	24884	24895	25645	26296	0.97
Yukon vehicle registration	19325	19942	20678	21486	22878	0.98
Average monthly border crossings from Alaska	1407	1658	975	1086	1292	-
Yukon retail trade in 1977 dollars x 10^3	22498	23201	22094	24464	25854	0.82

Table 5 shows relatively high gasoline sales in Whitehorse in the period of 77/78 relative to the sales in Yukon. The reasons for this are examined in Table 6 which shows ratios of fuel sales and other supporting data in Whitehorse and the Yukon. As can be seen from the table, there is no clear reason for high gasoline sales in Whitehorse for the period of 77/78 because all of the ratios in Table 6, except those involving gasoline sales in Whitehorse in 77/78, are very stable. It was decided, therefore, to adjust the gasoline sales of 77/78 in Whitehorse using the average gasoline sales ratio of 0.44 for Whitehorse to the Yukon in the period of 78/79 to 81/82 (using this gasoline sales ratio of 0.44 for 77/78 period, total gasoline sales in Whitehorse in 77/78 changes to 6535 x 10^3 litres (see Table 5 in parenthesis)).

A linear regression of the supporting data for the 5 month period was performed to examine the correlation coefficient R. The Whitehorse gasoline sales

TABLE 6 COMPARISON OF WHITEHORSE AND THE YUKON STATISTICS

	77/78	78/79	79/80	80/81	81/82
Gas sales Whitehorse / Gas sales Yukon	0.50 (0.44)	0.43	0.46	0.43	0.44
Gas sales Whitehorse / Population Whitehorse (L/Person)	485 (418)	414	422	426	416
Population Whitehorse / Population Yukon	0.66	0.67	0.68	0.68	0.68
Vehicle registr. Yukon / Population Yukon cars/person	0.81	0.80	0.83	0.84	0.87
Gas sales Yukon / Population Yukon (l/person)	630	640	630	672	646
Gas sales Yukon / Vehicle reg. + monthly border cross. (l/car)	725	737	720	764	703
Gas sales Yukon / Trade Yukon L/$1000	668	686	705	705	657
Average monthly border crossings / Car registr Yukon + monthly border cross x 100 %	6.8	7.7	4.5	4.8	5.4

regression was performed using the corrected 77/78 gasoline sales value. A regression of the gasoline sales for both Whitehorse and the Yukon was performed for only the 77/78 to 80/81 periods (period 81/82 was excluded since it was affected by the "Test and Tune" program). All other supporting data were regressed over all 5 periods. As can be seen from Table 5, the correlation coefficients are large and therefore show a high degree of positive association between variables.

Table 6 shows, that all ratios of gasoline sales in the Yukon to population, vehicle registration average monthly border crossings and, to Yukon retail trade are lower for 81/82 period, when compared to the period of 80/81. This confirms the effect of the

"test and tune" program. It should be noted that border crossings have little effect on gasoline sales in the Yukon. Under the assumption that vehicles crossing border remain in Yukon for period of one month (which is a probable overestimation), the increase in car population of the Yukon due to these vehicles is only 6 percent (see Table 6).

Therefore the relative impact of border crossing from Alaska on gasoline sales will be somewhat smaller in the city of Whitehorse. It is therefore very interesting that gasoline sales per capita are more than 30% higher in the rest of the Yukon than in the city of Whitehorse, see Table 6.

4.1 Effect of the "Test and Tune" Program on Fuel Sales in Whitehorse and the Yukon

To estimate the effect of the "Test and Tune" program on fuel sales in Whitehorse and the Yukon, reported fuel sales[5] for the 81/82 period were taken as a base. Fuel sales w/o "test and tune" program for 81/82 period were obtained by extrapolating from the linear regression of fuel sales over 77/78 to 80/81 periods, as in Table 7.

TABLE 7

	77/78	78/79	79/80	80/81	81/82	%
Actual Whitehorse gas sales, L x 10^3	6535	6874	7106	7400	7397	
Regressed Whitehorse gas sales, L x 10^3	6554	6837	7102	7403	7686	
Decrease of gas sales in 81/82, L x 10^3					289	3.76
Actual Yukon gas sales, L x 10^3	15022	15927	15580	17246	16998	
Regressed Yukon gas sales, L x 10^3	14995	15628	16260	16893	17525	
Decrease of gas sales in 81/82, L x 10^3					527	3.01

Table 7 indicates that the gasoline sales in Whitehorse and in the Yukon decreased in the 81/82 period of the "Test and Tune" program by 3.76 and 3.01 percent respectively.

Using the average ratio of CO emission improvement to fuel consumption improvement of 9.94 from Table 4, CO air quality improvement in Whitehorse for calm weather ($C_1 = 0$) can be calculated as follows:

$$9.94 \times 3.76 = 37.36\%$$

Thus, the theoretically possible drop in CO concentration in Whitehorse calculated from the decrease in gasoline sales compares well with the real drop in CO concentration (34%) measured at Federal Building monitoring station for calm days ($C_1 = 0$), see Table 3.

Conclusions

1) Ambient air quality measurements corrected for temperature, and windspeed indicate that ambient CO levels in Whitehorse on calm days were 34% lower for the winter period following the "Test and Tune" project.
2) Based on the relationship between CO emissions and fuel consumption resulting from improper idle mixture adjustment that has been developed in laboratory work, the observed reduction in ambient CO correlates well with the measured reduction in fuel sales in Whitehorse of 3.76% for the winter months following the program. The experimental work has shown that 9.94% reduction in mass CO emissions due to restorative maintenance is accompanied by a 1% reduction in fuel consumption. Given the 3.76% lower fuel sales, a CO emission reduction of 3.76 x 9.94 = 37.4% would therefore be expected.

REFERENCES

1. M.E. Smith, "Recommended Guide for the Prediction of the Dispersion of Airborne Effluents", ASME, 1973.

2. N. Ostrouchov, "Vehicle Emissions and Fuel Consumption in Canadian Winter Temperatures", APCA, Report 80-1,3, 1980.

3. D.L. Liljodal et al, "Study of Exhaust Emissions from 1972 through 1975 Model Year Light-Duty Vehicles in Denver", EPA, Report PB-276 967, 1976.

4. Unpublished ETL data.

5. Environment Canada, "An Evaluation of the Impact of the "Test and Tune" Program on Gasoline Sales in Whitehorse, Yukon", Hickling-Partners Inc., Report No. MPO 549, 1982.

6. Environment Canada, "Control of Excessive Emissions and Fuel Consumption by In-Use Motor Vehicles" Report EPS 3-AP-81-2, August 1981.

Consultant's Report on the Impact of "Test and Tune" on Gasoline Sales in Whitehorse

1 INTRODUCTION

As part of the air quality analysis, an estimate of the reduction in fuel sales attributable to the "Test and Tune" program was made by doing a linear regression of total fuel sales for Nov. Dec., Jan., Feb., and Mar. against calander year. The calculated result indicated a 3.8% reduction in total sales after the "Test and Tune" program. However, no statistical analysis as to the validity of the result was performed.

In order to fully investigate the effectiveness of the program in saving fuel, Hickling-Partners Inc. were hired to analyse records for fuel sales in Whitehorse prior to the program with a view to establishing trendlines which could be used to predict the level of fuel sales that would have occurred without "Test and Tune". A summary of the consultant's report as attached for examination by the reader.

IMPACT OF THE "TEST AND TUNE" PROGRAM ON GASOLINE SALES IN WHITEHORSE - A CONTRACTOR STUDY BY HICKLING-PARTNERS INC.

1 The objective of this study was to collate and analyse information on gasoline sales in Whitehorse and the Yukon Territory in order to measure the effect of the Inspection/Maintenance Demonstration Project on community gasoline consumption.

Data collected for this purpose included:

- gasoline sales in Whitehorse and the Yukon,
- motor vehicle registrations in the Yukon,
- number of automobiles entering the Yukon from Alaska,
- average monthly temperature in Whitehorse,
- population figures of Whitehorse and the Yukon,
- gasoline prices in Whitehorse, and
- retail trade in the Yukon.

Where possible, data was reported on a monthly basis and covered the period January, 1977 to April, 1978 inclusive.

The analysis was performed using the following descriptive statistic:

- the ratio of gasoline sales in Whitehorse to gasoline sales in the rest of the Yukon.

The first step in determining whether the test and tune program had an impact on gasoline sales was a comparison of the ratio's values before the program (i.e., the historical ratio period January 1977 - July 1981) with the computed values covering the period during the program and the eight months following (i.e., the experimental ratio period August - March, 1982). It was assumed any significant changes in gasoline consumption would occur in the months immediately following the program and decrease with time. Further, due to heavy tourist traffic in the fall period which potentially masks the effect of the program, special attention was paid to the winter months' data.

Secondly, if in fact, there was a significant change in the ratio values, it would be necessary to determine if the change could be attributed to other exogenous factors or to the program. For this part of the analysis, the correlation coefficients (r^2) between gasoline sales (for both Whitehorse and the Yukon Territory) and each of the exogenous variables were calculated.

2 EXPECTED RESULTS

As stated earlier, the objective of the "Test and Tune" program was to measurably reduce the carbon monoxide emissions and fuel consumption of the vehicle fleet by improving engine efficiency and driving habits.

Of the approximately 15,000 vehicles registered in Whitehorse, 3,500 were inspected between June 12 and September 18, 1981 in the inspection lanes operated by employees of the Ministry of Industry and Tourism, Yukon Territorial Government. It should be noted that the total population of 15,000 includes diesel-powered trucks which were not included in the program. Also the vehicles tested tended to be higher use vehicles (i.e., newer cars). Overall it was estimated that over 40% of the total vehicle kilometres generated by gasoline-powered vehicles were affected by the program.

Smaller scale surveys in cities all across Canada, in conjunction with laboratory work, indicated that such programs are capable of reducing carbon monoxide emissions by half and can reduce fleet fuel consumption by roughly 3-5%. At the outset of the program, it was hypothesized by Environment Canada that, due to differences in vehicle usage patterns, the Whitehorse project could potentially cut carbon monoxide pollution by about 70% and reduce gasoline consumption by as much as 10%.

The objective of this study was to collate and analyse information on gasoline sales in Whitehorse and the Yukon, in order to measure the effect of the Inspection/Maintenance Demonstration Project on community gasoline consumption. Hickling-Partners Inc. was contracted to evaluate the overall impact of the test and tune program on the volume of gasoline sales in Whitehorse. The evaluation of any changes in carbon monoxide pollution (monitored by the National Air Pollution Surveillance station, Whitehorse) was the responsibility of Environment Canada.

3 STUDY APPROACH

The methodology originally proposed for this study was:

- to develop a historical database of statistics from which a model to forecast gasoline sales could be developed and a comparative analysis of the actual demand undertaken; and
- to perform a ratio analysis of gasoline sales in Whitehorse to gasoline sales in the rest of the Yukon (and/or in a similarly sized city in the same general geographic area) in order to assess if changes in fuel consumption occured.

The intention was to use these two techniques to produce comparative estimates of the effectiveness of the test and tune program in order to enhance the reliability of the study results.

To employ the model technique (i.e., develop an equation to forecast gasoline sales) the following data was required:

- there must be a sufficient amount of historical data - for the purposes of this study, data collected should date back at least to June 1975;
- there must be a sufficient number of exogenous parameters - input parameters identified were number of vehicles, fuel sales, population, temperature, economic activity;
- a significant amount of detail for each of the variables is required - this data is required on a monthly basis and must be available for the city of Whitehorse separately.

During the collection and assembly of the data, it was apparent that at least two of the above requirements could not be satisfied. Data was available only as far back as 1977 and often could not be provided by monthly breakdowns. As well, most information pertaining specifically to Whitehorse was not available. Based on these restrictions, it was determined that a forecast model could not be developed with sufficient accuracy to be statistically reliable.

However, information collected did meet the minimum requirements to perform a ratio analysis of the data. This technique* normalizes for changes in the base

*SAE 810192, Measurement of Effectiveness of Rear-Turn-Signal Systems in Reducing Vehicle Accidents.

demand due to economic, technological and/or population changes. It is based on the assumption that the two pools of data (in this case data for Whitehorse and Yukon) have parallel growth patterns. (The Yukon Territory was chosen as the control group for the analysis as data was more readily available for the whole of the Yukon than for any other proximate city.)

3.1 Methodology Employed

The 'gasoline sales' ratio is denoted by the following equation:

$$\text{ratio} = \frac{\text{Whitehorse gasoline sales}}{\text{Yukon gas sales - Whitehorse gas sales}}$$

With this method, the ratio of experimental (Whitehorse) data to control (Yukon) data is tracked from January, 1977 to July, 1981. The ratio values are then compared with the values during and eight months after the program. Statistical tests are then applied to determine if there was any significant change in fuel consumption patterns between the data sets.

The second step in the analysis examines the relationship between gasoline sales and several exogenous variables (i.e., border crossings, temperature, etc.) to assess whether the change in the ratio could be attributed to the program or to any of the factors identified.

3.2 Data Sources

The following is a list of the sources of data employed in this study. Where possible, data was collected on a monthly basis and covered the period January 1977 to May 1982.

3.2.1 Gasoline Sales in Whitehorse and the Yukon. Data for Whitehorse was obtained directly from the city's three suppliers: Gulf Canada, Imperial Oil and White Pass Petroleum Services. Data for the Yukon was obtained from the Department of Finance, Government of Yukon. Information was not always available on a monthly basis.

3.2.2 Motor Vehicle Registrations in the Yukon. Data on motor vehicle registrations was provided by the Motor Vehicle Branch, Department of Consumer and Corporate Affairs, Government of Yukon. Vehicle registration statistics are available only on an annual basis and could not be provided for the city of Whitehorse alone.

3.2.3 Number of Automobiles entering Yukon from Alaska. This data was collected to provide an indication of changes in the level of consumption versus size of the fleet. It is assumed that the level of border crossings will affect the size of the effective fleet which in turn would affect overall gasoline sales.

The most appropriate indicator was found to be the number of automobiles entering Yukon from Alaska. This data was obtained from Statistics Canada Catalogue 66-001 and the International Travel Section, Financial Flows and Multinational Enterprises Division, Statistics Canada, Ottawa. Data on border crossings was available on a monthly basis for the entire study period.

3.2.4 Average Monthly Temperature in Whitehorse. It was assumed that temperature has a bearing on average fuel efficiency of vehicles, e.g., longer warm-up periods are required for colder weather. Average daily and average low monthly temperatures in Whitehorse for the period studied were obtained from Environment Canada.

3.2.5 Population Figures of Whitehorse and the Yukon. Population figures were gathered on the assumption that a growth in the population of the city of Whitehorse would impact on the size of the urban fleet of vehicles. Annual data for both Whitehorse and Yukon were obtained from the Yukon Economic Review and monthly statistics were provided by the Department of Tourism and Economic Development, Government of Yukon.

3.2.6 Gasoline Prices in Whitehorse. Gasoline prices in Whitehorse were available for most months from 1977 to 1982. Information was provided by the Department of Tourism and Economic Development, Government of Yukon.

3.2.7 Retail Trade in the Yukon. Total retail trade was employed as an indicator of economic activity in the region based on the assumption that the level of economic activity would affect gasoline sales. Data were obtained from Statistics Canada Catalogue 63-005, and the Merchandising and Services Division, Statistics Canada. These data were available on a monthly basis for the entire study period for the Yukon, but not for the city of Whitehorse.

4 ASSEMBLED DATA

Tables 4-1 to 4-6 present a summary of all supporting data gathered for the analysis of the test and tune program for each year between 1977 and 1982, respectively. For each table, the following information is presented:

1) The first and second rows show the volume of gasoline sales in Whitehorse and the Yukon, respectively.
2) The third row reports the monthly gasoline sales ratio (e.g., row one divided by (row two less row one)).
3) Row four provides an estimate of the annual number of motor vehicle registrations in Whitehorse. As stated earlier, actual data on the number of motor vehicle registrations in Whitehorse was not available and, therefore, estimates have been used (see Table 4-7). The formula for the calculation of this estimate is the number of motor vehicle registrations in the Yukon multiplied by the corresponding Whitehorse/Yukon population ratio (e.g., the 1980 estimate of vehicle registrations in Whitehorse (14,567) is equal to the 1980 figure for vehicle registrations in the Yukon (21,486) multiplied by the 1980 Whitehorse/Yukon population ratio (16,362/24,138).
4) The fifth row reports the annual number of motor vehicle registrations for the Yukon Territory. These figures include private and commercial cars and trucks.
5) Row six presents the number of automobiles entering the Yukon from Alaska, and is a summary of the raw data reported in Table 4-8.
6) Rows seven and eight provide the average daily and average low monthly temperatures for Whitehorse, respectively.
7) The ninth and tenth rows provide population estimates for Whitehorse and Yukon Territory, respectively. Population figures were not always available for each month, especially prior to 1978. Tables 4-9 and 4-10 show which of the figures are reported by the Government of the Yukon and which have been estimated.
8) Rows eleven and twelve show the average monthly price of gasoline (regular leaded) in Whitehorse in current and constant 1977 dollars, respectively. Data on the price of gasoline is only available on a bi-monthly or quarterly basis. These monthly estimates of the price of gasoline have been derived in Table 4-11.
9) Rows thirteen and fourteen report retail trade in the Yukon in current and constant 1977 dollars, respectively.

Tables 4-7 to 4-11 contain data concerning Whitehorse and Yukon vehicle registrations, monthly border crossings, Whitehorse and Yukon population figures and the average Whitehorse retail price of regular leaded gasoline.

4.1 Analysis

The analysis procedures used to assess if the test and tune program had an impact on gasoline sales comprised:

- variance analysis of the Whitehorse fuel sales data and the Whitehorse/Yukon gasoline sales ratio; and
- determining if changes in the ratio can be attributed to exogenous factors one of which is the program.

As stated earlier, the first analytical procedure involved tracking the gasoline sales from January, 1977 to April, 1982 and statistically comparing the gasoline sales and sales ratio values for significant differences between before and after the program. Because of the large influx of tourist traffic in summer months, the data from the winter months between November and March reflect the local conditions most accurately.

It should be noted that if ratio increases between the control and experimental periods, then the amount of gasoline sales in Whitehorse has increased relative to the Yukon's. Conversely, if the ratio decreases, then the amount of gasoline sales in Whitehorse has decreased relative to sales for the Yukon. For the test and tune program to have been effective in decreasing gasoline sales in Whitehorse, it would be expected that the gasoline sales ratio would decrease in the period following the program.

In the second analytical procedure, several exogenous factors which could conceivably have an effect on gasoline demand were identified. They are:

- border crossings,
- temperature,
- population,
- price of gasoline,
- retail trade volumes, and
- the program itself.

To examine the relationship between gasoline sales and each of the above factors, correlation coefficients (r^2) were calculated. The value (r^2) is an indicator of the degree of association between two data sets but a strong relationship (association)

TABLE 4-1 MONTHLY STATISTICS - WHITEHORSE AND THE YUKON, 1977

Indicator	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1977
Whitehorse Gas Sales (kilolitres)	N/A	942	1099	1249	1377	1590	1876	1993	1607	1491	1656	1689	
Yukon Gas Sales (kilolitres)	2264	2494	3071	3134	3628	5774	6625	6883	4911	3748	3341	3227	49099
Whitehorse/Yukon Ratio[1]	N/A	0.607	0.557	0.662	0.611	0.380	0.395	0.408	0.486	0.660	0.982	1.098	
Whitehorse Vehicle Registrations	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12542
Yukon Vehicle Registrations	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19325
Border Crossings[2]	1526	1291	1925	2197	3245	4996	7625	7266	3641	2822	1689	1455	39678
Average Temp (°C)	-7.7	-2.8	-6.7	2.2	6.4	11.2	13.3	15.0	7.0	2.2	-13.9	-26.1	
Average Low Temp (°C)	-12.2	-7.1	-12.3	-3.1	-0.1	4.1	6.9	7.7	1.6	-1.2	-13.3	-30.2	
Whitehorse Population	N/A	N/A	N/A	N/A	N/A	14725	14853	15031	15157	15350	15497	15588	
Yukon Population	N/A	N/A	N/A	N/A	N/A	22698	22846	23113	23209	23491	23652	23791	
Gasoline Price ($/Litre)[3]	N/A	N/A	N/A	N/A	N/A	0.2398	0.2409	0.2420	0.2431	0.2442	0.2453	0.2464	
Gasoline Price ($/Litre)[4]	N/A	N/A	N/A	N/A	N/A	0.2297	0.2290	0.2277	0.2283	0.2263	0.2253	0.2250	
Yukon Retail Trade ($000)[3]	3565	3401	3933	4963	5617	6569	6129	6148	6086	5485	5184	6216	63296
Yukon Retail Trade ($000)[4]	3565	3362	3834	4807	5403	6292	5827	5785	5716	5084	4762	5676	

Notes: N/A Not available

1) $\frac{\text{Whitehorse Gas Sales}}{\text{(Yukon-Whitehorse) Gas Sales}}$
2) Number of autos entering Yukon from Alaska
3) Current dollars
4) In constant January, 1977 dollars, based on CPI for Edmonton

TABLE 4-2 MONTHLY STATISTICS - WHITEHORSE AND THE YUKON, 1978

Indicator	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1978
Whitehorse Gas Sales (kilolitres)	1288	1417	1524	1616	1814	1853	2027	2310	1870	1554	1625	1542	20439
Yukon Gas Sales (kilolitres)	2766	2535	3153	3356	3936	5018	5900	9084	5037	4137	3794	2942	51657
Whitehorse/Yukon Ratio[1]	0.871	1.267	0.935	0.929	0.855	0.585	0.523	0.341	0.590	0.602	0.749	1.102	0.655
Whitehorse Vehicle Registrations	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13142
Yukon Vehicle Registrations	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19942
Border Crossings[2]	1101	1161	1629	2379	3638	6980	10688	9446	5866	3700	2333	1810	50731
Average Temp (°C)	-18.0	-9.6	-5.1	1.1	6.6	11.6	14.0	13.2	7.7	3.5	-10.2	-13.8	
Average Low Temp (°C)	-22.3	-15.4	-9.9	-5.0	0.3	4.9	7.1	6.8	1.9	3.5	-14.0	-18.7	
Whitehorse Population	15620	15644	15734	15780	15396	15238	15455	15844	15994	16267	16576	16618	
Yukon Population	23829	23847	23980	23970	23353	23140	23306	23797	24114	24441	24850	24968	
Gasoline Price ($/Litre)[3]	0.2475	0.2486	0.2519	0.2552	0.2497	0.2442	0.2442	0.2442	0.2442	0.2442	0.2420	0.2398	
Gasoline Price ($/Litre)[4]	0.2248	0.2247	0.2256	0.2270	0.2199	0.2133	0.2118	0.2116	0.2114	0.2087	0.2050	0.2026	
Yukon Retail Trade ($000)[3]	3840	4472	5057	5592	6559	7309	6841	6902	6358	5936	5373	7469	71708
Yukon Retail Trade ($000)[4]	3488	4043	4529	4974	5777	6383	5935	5981	5503	5073	4551	6309	

Notes: N/A Not available

1) $\frac{\text{Whitehorse Gas Sales}}{\text{(Yukon-Whitehorse) Gas Sales}}$

2) Number of autos entering Yukon from Alaska

3) Current dollars

4) In constant January, 1977 dollars, based on CPI for Edmonton

TABLE 4-3 MONTHLY STATISTICS - WHITEHORSE AND THE YUKON, 1979

Indicator	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1979
Whitehorse Gas Sales (kilolitres)	1207	1179	1321	1440	1655	1724	1984	2132	1783	1730	1600	1684	19447
Yukon Gas Sales (kilolitres)	2811	2771	3609	3308	3984	5727	5404	8365	4917	4522	2828	3750	51996
Whitehorse/Yukon Ratio[1]	0.752	0.741	0.581	0.772	0.711	0.431	0.580	0.342	0.569	0.619	1.304	0.815	0.597
Whitehorse Vehicle Registrations	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13937
Yukon Vehicle Registrations	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20678
Border Crossings[2]	1455	982	1712	2160	4016	8151	9992	9935	5666	3324	1256	918	49567
Average Temp (°C)	-22.2	-28.0	-4.4	1.7	6.6	11.1	13.7	13.9	8.4	3.3	-3.6	-16.2	
Average Low Temp (°C)	-27.2	-33	-9.3	-6.3	0.4	5.5	7.9	6.2	3.0	-0.8	-6.6	-21.2	
Whitehorse Population	16555	16663	16676	16716	16157	16191	16305	16296	16476	16624	16686	16847	
Yukon Population	24829	24888	24883	24809	23966	24007	24188	24254	24489	24687	24675	24865	
Gasoline Price ($/Litre)[3]	0.2431	0.2464	0.2497	0.2530	0.2541	0.2552	0.2563	0.2574	0.2640	0.2706	0.2783	0.2859	
Gasoline Price ($/Litre)[4]	0.2045	0.2040	0.2047	0.2059	0.2055	0.2048	0.2040	0.2051	0.2083	0.2123	0.2168	0.2215	
Yukon Retail Trade ($000)[3]	4417	4670	5806	5327	5880	7121	7381	7924	6658	6748	6317	7603	75852
Yukon Retail Trade ($000)[4]	3715	3867	4759	4336	4756	5715	5875	6314	5254	5295	4922	5891	

Notes: N/A Not available

1) $\frac{\text{Whitehorse Gas Sales}}{\text{(Yukon-Whitehorse) Gas Sales}}$

2) Number of autos entering Yukon from Alaska

3) Current dollars

4) In constant January, 1977 dollars, based on CPI for Edmonton

TABLE 4-4 MONTHLY STATISTICS - WHITEHORSE AND THE YUKON, 1980

Indicator	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1980
Whitehorse Gas Sales (kilolitres)	1258	1256	1308	1558	1954	2006	2449	2545	2076	1795	1600 1401	1792 1992	21597
Yukon Gas Sales (kilolitres)	2941	2782	3279	3759	4732	8869	7952	7848	6224	4775	3433	4184	60772
Whitehorse/Yukon Ratio[1]	0.748	0.823	0.664	0.708	0.703	0.292	0.445	0.480	0.500	0.603	.87 0.689	.75 0.908	0.551
Whitehorse Vehicle Registrations	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14567
Yukon Vehicle Registrations	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21486
Border Crossings[2]	755	746	1200	1697	3201	6069	9641	9814	5010	2452	1425	973	42983
Average Temp (°C) Average Low Temp (°C)	-21.2 -25.8	-8.4 -13.0	-6.2 -11.3	3.2 -1.4	7.2 -0.1	13.5 5.9	14.0 8.0	11.5 5.3	5.9 1.5	3.5 3.5	-3.3 -6.2	-27.6 -31.8	
Whitehorse Population	16908	16844	16929	16898	16204	16362	16444	16649	16738	17002	17118	17260	
Yukon Population	24948	24914	25062	24954	23892	24138	24269	24569	24753	25121	25291	25515	
Gasoline Price ($/Litre)[3]	0.2859	0.2859	0.2969	0.3079	0.3123	0.3167	0.3211	0.3255	0.3299	0.3424	0.3548	0.3673	
Gasoline Price ($/Litre)[4]	0.2202	0.2183	0.2242	0.2303	0.2310	0.2320	0.2338	0.2350	0.2353	0.2410	0.2454	0.2530	
Yukon Retail Trade ($000)[3]	4797	4506	5489	6856	7262	8181	8448	9216	8081	7494	7045	9222	86597
Yukon Retail Trade ($000)[4]	3695	3441	4145	5127	5371	5993	6151	6654	5764	5275	4872	6352	

Notes: N/A Not available

1) $\frac{\text{Whitehorse Gas Sales}}{\text{(Yukon-Whitehorse) Gas Sales}}$

2) Number of autos entering Yukon from Alaska

3) Current dollars

4) In constant January, 1977 dollars, based on CPI for Edmonton

TABLE 4-5 MONTHLY STATISTICS - WHITEHORSE AND THE YUKON, 1981

Indicator	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1981
Whitehorse Gas Sales (kilolitres)	1173	1305	1529	1599	1832	2288	2667	2461	2064	1688	1413	1588	21069
Yukon Gas Sales (kilolitres)	2870	2974	3785	4094	4554	6643	8612	8383	6258	5252	3603	3308	60335
Whitehorse/Yukon Ratio[1]	0.691	0.782	0.677	0.640	0.673	0.525	0.449	0.415	0.492	0.474	0.645	0.923	0.537
Whitehorse Vehicle Registrations	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15511
Yukon Vehicle Registrations	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22878
Border Crossings[2]	911	813	1308	1631	3960	7659	12561	12851	6234	3089	1576	1246	53839
Average Temp (°C)	-4.0	-11.4	-2.1	-2.1	8.9	10.6	14.4	12.9	6.4	1.7	-4.8	-16.3	
Average Low Temp (°C)	-7.5	-16.1	-7.0	-7.3	1.8	4.2	7.7	7.1	1.6	-1.6	-8.1	-20.4	
Whitehorse Population	17370	17412	17610	17756	17782	17023	17167	17361	17548	17704	17859	17911	
Yukon Population	25683	25727	26011	26169	26152	25121	25318	25590	25955	26171	26387	26445	
Gasoline Price ($/Litre)[3]	0.3805	0.3937	0.4069	0.4179	0.4289	0.4399	0.4465	0.4531	0.4597	0.4597	0.4597	0.4597	
Gasoline Price ($/Litre)[4]	0.2590	0.2662	0.2729	0.2788	0.2818	0.2848	0.2861	0.2890	0.2916	0.2889	0.2852	0.2845	
Yukon Retail Trade ($000)[3]	6624	5763	7210	7647	9331	10807	11844	12088	10561	9741	9275	11875	112766
Yukon Retail Trade ($000)[4]	4508	3897	4835	5101	6132	6998	7590	7711	6698	6123	5755	7351	

Notes: N/A Not available

1) $\frac{\text{Whitehorse Gas Sales}}{\text{(Yukon-Whitehorse) Gas Sales}}$
2) Number of autos entering Yukon from Alaska
3) Current dollars
4) In constant January, 1977 dollars, based on CPI for Edmonton

TABLE 4-6 MONTHLY STATISTICS - WHITEHORSE AND THE YUKON, JAN.-APR., 1982

Indicator	Jan.	Feb.	Mar.	Apr.
Whitehorse Gas Sales (Kilolitres)	1,318	1,428	1,650	1,475
Yukon Gas Sales (kilolitres)	3,173	3,021	3,893	3,449
Whitehorse/Yukon Ratio	0.710	0.901	0.736	0.748
Whitehorse Vehicle Registrations	N/A	N/A	N/A	N/A
Yukon Vehicle Registrations	N/A	N/A	N/A	N/A
Border Crossings[2]	1,153	910	1,573	2,181
Average Temp (°C)	-31.2	-18.1	-9.4	-2.2
Average Low Temp (°C)	-35.6	-22.9	-15.4	-7.6
Whitehorse Population	18,003	18,033	17,140	15,885
Yukon Population	26,551	26,625	25,473	23,655
Gasoline Price ($/litre)[3]	0.4578	0.4599	0.4600	0.4734
Gasoline Price ($/litre)[4]	0.2809	0.2787	0.2755	0.2801
Yukon Retail Trade ($000)[3]	6,893	6,697	7,448	7,902
Yukon Retail Trade ($000)[4]	4,229	4,059	4,460	4,676

Notes: N/A Not available

1) $\frac{\text{Whitehorse Gas Sales}}{\text{(Yukon-Whitehorse) Gas Sales}}$
2) Number of autos entering Yukon from Alaska
3) Current dollars
4) In constant January, 1977 dollars, based on CPI for Edmonton

TABLE 4-7 WHITEHORSE VEHICLE REGISTRATION ESTIMATES

Factor	Year					
	1977	1978	1979	1980	1981	1982 (Jan-May)
Whitehorse Pop. (000's)[1]	14,725	15,238	16,191	16,362	17,023	15,581
Yukon Pop. (000's)[1]	22,687	23,140	24,007	24,138	25,121	23,180[4]
Yukon Pop. Ratio	.649	.659	.674	.678	.678	.672
Yukon Vehicle Registrations[2]	19,325	19,942	20,678	21,486	22,878	17,464
Whitehorse Vehicle Estimates[3]	12,542	13,142	13,937	14,567	15,511	11,738

1) June figures
2) Includes private and commercial cars and trucks
3) Estimates derived by applying the Whitehorse/Yukon population ratio to the Yukon vehicle registration figures
4) May figures

Sources: Yukon Economic Review, and the Department of Consumer and Corporate Affairs, Government of Yukon.

TABLE 4-8 NUMBER OF AUTOMOBILES ENTERING YUKON FROM ALASKA, BY COUNTRY OF RESIDENCE AND MONTH, 1977-1981

	1977			1978			1979			1980			1981		
Month	U.S.	Can.	Tot.	U.S.	Can.	Tot.	U.S.	Can.	Tot.	U.S.	Can.	Tot.	U.S.	Can.	Tot.
January	1466	60	1526	1055	46	1101	1401	54	1455	702	53	755	870	41	911
February	1203	88	1291	1066	95	1161	921	61	982	671	75	746	735	78	813
March	1792	133	1925	1465	164	1629	1596	116	1712	1090	110	1200	1101	207	1308
Q1 Total	4461	281	4742	3586	305	3891	3918	231	4149	2463	238	2701	2706	326	3032
April	1942	255	2197	2184	195	2379	1846	314	2160	1311	386	1697	1258	373	1631
May	2793	452	3245	3078	560	3638	2864	1152	4016	2263	938	3201	2526	1434	3960
June	4512	484	4996	5810	1170	6980	6433	1718	8151	4479	1590	6069	5369	2290	7659
Q2 Total	9247	1191	10438	11072	1925	12997	11143	3184	14327	8053	2914	10967	9153	4097	13250
July	6399	1226	7625	8754	1934	10688	7266	2726	9992	6717	3124	9641	8569	3992	12561
August	6277	989	7266	7709	1737	9446	7445	2490	9935	6565	3249	9814	9296	3555	12851
September	3202	439	3641	5077	789	5866	4406	1260	5666	3710	1300	5010	4848	1386	6234
Q3 Total	15878	2654	18532	21540	4460	26000	19117	6476	25593	16792	7673	24465	22713	8933	31646
October	2624	198	2822	3403	297	3700	2833	491	3324	1939	513	2452	2515	574	3089
November	1622	67	1689	2198	135	2333	1167	89	1256	1222	203	1425	1411	165	1576
December	1405	50	1455	1684	126	1810	866	52	918	934	39	973	1184	62	1246
Q4 Total	5651	315	5966	7285	558	7843	4866	632	5498	4095	755	4850	5110	801	5911
Total	35237	4441	39678	43483	7248	50731	39044	10523	49567	31403	11580	42983	39682	14157	53839

Sources: Government of Yukon, Department of Tourism and Economic Development, and Statistics Canada Catalogue 66-001.

TABLE 4-9 POPULATION OF WHITEHORSE

	Year					
Month	1977	1978	1979	1980	1981	1982
January		15620*	16555	16908	17370	18003
February		15644*	16663	16844	17412	18033
March		15734*	16676	16929	17610	17140
April		15780*	16716	16898	17756	15885
May		15396*	16157	16204	17782	15581
June	14725*	15238*	16191	16362	17023	
July	14853*	15455	16305	16444	17167	
August	15031*	15844	16296	16649	17361	
September	15157	15944	16476	16738	17548	
October	15350*	16267	16624	17002	17793*	
November	15497*	16576	16686	17118	17859	
December	15588*	16618	16847	17260	17911	

*Estimate based on the average monthly growth rate for the same respective period

Source: Department of Tourism and Economic Development, Government of Yukon, figures derived from the Health Care Records.

TABLE 4-10 POPULATION OF THE YUKON TERRITORY

Month	Year					
	1977	1978	1979	1980	1981	1982
January		23829*	24829	24958	25683	26551
February		23847*	24888	24914	25727	26625
March		23980*	24883	25062	26011	25473
April		23970*	24809	24954	26169	23655
May		23353*	23966	23892	26152	23180
June	22687*	23140*	24007	24138	25121	
July	22846*	23306	24188	24269	25318	
August	23113*	23797	24254	24569	25590	
September	23209	24114	24489	24753	25955	
October	23491*	24441	24687	25121	26271*	
November	23652*	24850	24675	25291	26387	
December	23791*	24968	24865	25515	26445	

*Estimate based on the average monthly growth rate for the same respective period

Source: Department of Tourism and Economic Development, Government of Yukon, figures derived from the Health Care Records.

TABLE 4-11 AVERAGE WHITEHORSE PRICES OF REGULAR LEADED GASOLINE ($/LITRES)

	Year					
Month	1977	1978	1979	1980	1981	1982
January		0.2475*	0.2431	0.2859*	0.3805*	0.4598
February		0.2486	0.2464	0.2859	0.3937*	0.4599
March		0.2519*	0.2497*	0.2969*	0.4069	0.4600
April		0.2552	0.2530	0.3079	0.4179*	0.4734
May		0.2497*	0.2541*	0.3123*	0.4289*	0.4868
June	0.2398	0.2442	0.2552	0.3167	0.4399	0.5002
July	0.2409*	0.2442*	0.2563*	0.3211*	0.4465*	
August	0.2420*	0.2442	0.2574	0.3255*	0.4531*	
September	0.2431*	0.2442*	0.2640*	0.3299	0.4597	
October	0.2442*	0.2442	0.2706	0.3424*	0.4597*	
November	0.2453*	0.2420*	0.2783*	0.3548*	0.4597*	
December	0.2464	0.2398	0.2859	0.3673	0.4597	

*Estimate based on linear interpolation respective period

Source: Department of Tourism and Economic Development, Government of Yukon.

between the two does not necessarily imply that a change in one data set will "cause" a change in the other. To determine this causal relationship, a theoretical model is required.

For this study, the exogenous factors were compared after the test and tune period against the pre-program trends and if significant changes can be detected, then the change in consumption could be attributed to the "test and tune" program itself.

4.2 Gasoline Sales Ratio

The gasoline sales ratio derived in the summary tables, has been presented graphically in Figure 4-1. From this graph, a consistent annual trend in fuel consumption is evident. Generally, the consumption pattern changes such that the ratio reaches its high in the winter, (highest proportion Whitehorse sales) decreases in the spring, reaches a nadir in the summer (lowest proportion Whitehorse sales) at which time it increases through the fall again to the winter high.

In general, the 1981 trend of the fuel sales ratio follows the historical pattern and is within the historical experience. However, when statistical analysis is undertaken on the ratio data to determine the occurance of statistically different data by month (see Tables 4-12 and 4-13), it is apparent that only one month (October) is different (at 95% confidence). All other points are within the 95% confidence band defined by the historical experience.

Further, an analysis of the absolute fuel sales in Whitehorse (Table 4-13) indicates no statistically significant changes but a general trend towards increased fuel sales in 1981 compared to the historical average. As a result of the normality of the Whitehorse sales, the conclusion must be made that Yukon sales have increased significantly in October. This is confirmed when the 4 years of data (2653 kl average with a standard deviation of 310 kl) is compared to 1981 sales (3564 kl).

Thus, the post-program data indicates a significant decrease in Whitehorse fuel consumption did occur (in October only) relative to the sales in the rest of the Yukon when compared to the four year historical experience. The next section will investigate the possible variables which could explain such a drop in Whitehorse gas sales.

4.3 Exogenous Variables

To examine the level of variable interaction, correlation coefficients (r^2) between gasoline sales (for both Whitehorse and the Yukon) and each of the exogenous

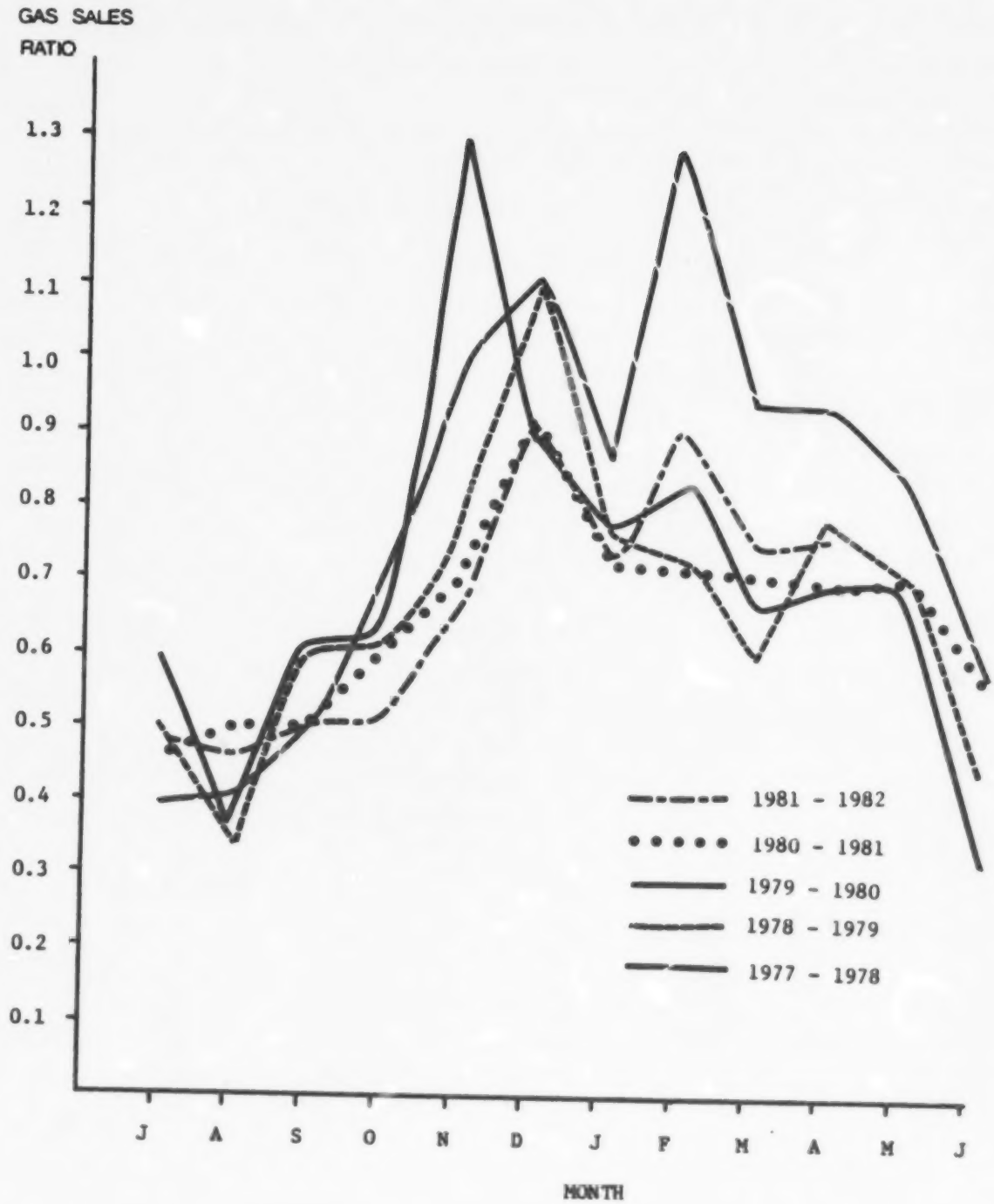


FIGURE 4-1 HISTORICAL AND EXPERIMENTAL GASOLINE SALES RATIOS

TABLE 4-12 PERCENTAGE CHANGE IN MONTHLY GASOLINE SALES RATIO

Month	1977-80 Ratio		Current Ratio		% Change* in Ratio		Significant Difference**
	Mean	Std. Dev.	1981	1982	1981	1982	
January	0.77	0.06	0.69	0.71	-10.4	-7.8	NO
February	0.84	0.22	0.78	0.90	-7.1	+7.1	NO
March	0.68	0.13	0.68	0.74	-0.0	+8.8	NO
April	0.74	0.10	0.64	0.75	-13.5	+1.4	NO
May	0.71	0.10	0.67		-6.9		—
June	0.42	0.12	0.53		+26.2		—
July	0.46	0.08	0.45		-2.2		—
August	0.39	0.07	0.42		+7.7		NO
September	0.54	0.05	0.49		-9.3		NO
October	0.62	0.03	0.47		-24.2		YES
November	0.93	0.28	0.65		-30.1		NO
December	0.98	0.14	0.92		-6.1		NO

* from 1977-80 base.
** post program months only at 95% confidence.

TABLE 4-13 CHANGE IN MONTHLY GASOLINE SALES IN WHITEHORSE

Month	1977-80 Sales (K1)		Current Sales (K1)		% Change* in Sales		Significant Difference**
	Mean	Std. Dev.	1981	1982	1981	1982	
January	1251	41	1173	1317	-6.2	+5.3	NO
February	1198	198	1305	1427	+8.9	+19.1	NO
March	1314	174	1529	1650	+16.4	+25.6	NO
April	1466	161	1599	1475	+9.1	+0.7	NO
May	1700	248	1832		+7.8		—
June	1793	178	2288		+27.6		—
July	2084	251	2667		+28.0		—
August	2245	239	2461		+9.6		NO
September	1834	195	2064		+12.5		NO
October	1642	143	1688		+2.8		NO
November	1570	115	1413		-10.0		NO
December	1727	190	1588		-8.0		NO

* from 1977-80 base.
** post program months only at 95% confidence level.

variables were calculated. The results are shown for Yukon sales in Table 4-14, and Whitehorse sales in Table 4-15.

- Border crossings, of all the exogenous variables under investigation, have the highest consistent correlation to gasoline sales in Whitehorse and the Yukon. This makes intuitive sense as the level of border crossings directly affects the size of a resident motor vehicle fleet and, hence, gasoline consumption. Most of these automobiles (over 80 percent) are registered in the U.S. and, therefore, would clearly increase the effective size of a fleet (see Table 4-8). The relative impact, however, tends to be higher on gasoline sales in the Yukon than in Whitehorse (e.g., the correlation coefficient is generally higher for the Yukon than for Whitehorse, as shown in Tables 4-14 and 4-15).

The level of border crossings is presented graphically in Figure 4-2, for 1977 to 1981. Note that the level of border corssings in the period following the test and tune program (September to December 1981) falls within the historical range, indicating that the level of border crossings exhibited no significant change from historical levels in the fourth quarter of 1981. In particular, the October volume was not significantly different than in the four previous years.

- Temperature exhibits a relatively strong correlation to fuel usage. This can be explained by the increase in vehicle use and influx of traffic in the summertime. From a specific gasoline consumption viewpoint, there is a negative correlation with temperature (i.e., the lower the temperature the higher the consumption rate per kilometre). The influence of this effect could only be relevant if the monthly temperatures were significantly different during the experimental period and the historical period. From Tables 4-1 through 4-5, the following data on the test months is extracted:

	Monthly Average Temperature (°C)			
Year	Sept.	Oct.	Nov.	Dec.
1977	-7.0	-2.2	-13.9	-26.1
1978	7.7	3.5	-10.2	-13.8
1979	8.4	3.3	-3.6	-16.2
1980	5.9	3.5	-3.3	-27.6
1981	6.4	1.7	-4.9	-16.3

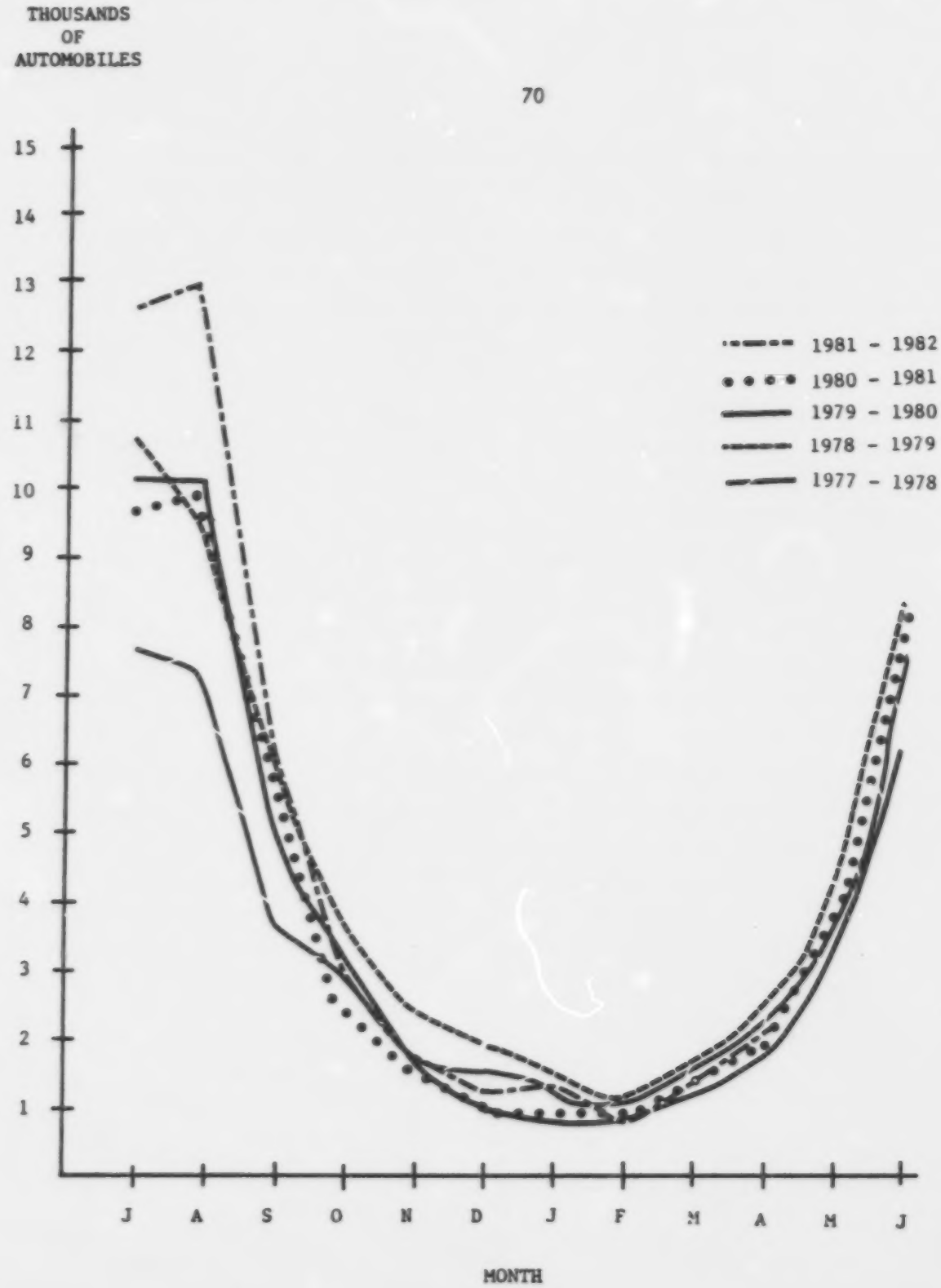


FIGURE 4-2 BORDER CROSSINGS FROM ALASKA TO THE YUKON

TABLE 4-14 CORRELATION COEFFICIENTS (R^2) BETWEEN YUKON GAS SALES AND A FEW SELECT VARIABLES

	Year				
Variable	1977	1978	1979	1980	1981
Border Crossings	.936	.777	.793	.834	.957
Average Temp.	.531	.583	.534	.533	.820
Pop. of Yukon	***	.100	.403	.404	.321
Gasoline Price*	***	.095	.014	.042	.419
Gasoline Price**	***	.123	.053	.041	.513
Retail Trade*	.564	.299	.576	.530	.857
Retail Trade**	.607	.307	.642	.611	.888

* Current dollars
** Constant dollars
*** Insufficient data

TABLE 4-15 CORRELATION COEFFICIENTS (R^2) BETWEEN WHITEHORSE GAS SALES AND A FEW SELECT VARIABLES

	Year				
Variable	1977	1978	1979	1980	1981
Border Crossings	.512	.824	.668	.781	.784
Average Temp.	.062	.741	.664	.328	.701
Pop. of Whitehorse	***	.050	.268	.236	.397
Gasoline Price*	***	.059	.169	.172	.249
Gasoline Price**	***	.128	.017	.181	.424
Retail Trade*	.731	.495	.831	.783	.506
Retail Trade**	.679	.518	.840	.845	.568

* Current dollars
** Constant dollars
*** Insufficient data

It is clear from these data that the average monthly temperatures for 1981 were not outside the historical range of temperatures experienced in the control period. On this basis, temperature can be dismissed as an explanatory variable.

Population appears to have little impact on the level of gasoline sales. The correlation coefficient (r) was found to be a negative number in all cases. This infers that the relationship between population and volume of gasoline sales was directionally negative, i.e., as population increases the level of gasoline consumption decreases. As shown in Tables 4-9 and 4-10, the "official" total population in Whitehorse and the Yukon tends to decrease in the summer just when the tourist trade increases. According to Yukon government employees, this "loss" in population is due to the fact many native people engage in traditional activities during this time, i.e., a significant number of people have left the urban areas such as Whitehorse, temporarily migrating to more remote areas as fishing guides, and subsequently have not been enumerated. The variance of the "population" in the experimental period is not outside the historical range and, thus, population cannot be considered an explanatory variable.

- The price of gasoline, by itself, appears to have little effect on the level of gasoline sales. However, note is taken of the increased value for 1981, which implies that in 1981 the relationship between gasoline sales and the price of gasoline was directionally positive, i.e., as the price of gasoline rose, consumption increased. This weak counter-intuitive result is most probably an artifact of the poor correlation. An analysis of Tables 4-5, 4-6 and Figure 4-3 shows that the price of gasoline has not changed substantially in the last half of 1981 and first quarter of 1982. Hence, due to the weak relationship between gasoline price and sales, and the static nature of the recent price history, the price of gasoline can be eliminated as a pertinent explanatory variable.
- Retail trade, as an indicator of economic activity, appears to have a significant correlation with gasoline sales. The relationship between gasoline sales and retail trade is directionally positive (i.e., as the level of retail trade increases so does the level of gasoline sales). The r^2 coefficient was generally above 0.5, i.e., marginally significant.

Total retail trade in the Yukon has been graphed in Figure 4-4, from 1977 to 1981. The figures have been expressed in terms of constant January 1977 dollars. To deflate the statistics, the Consumer Price Index (CPI) for the city of Edmonton was

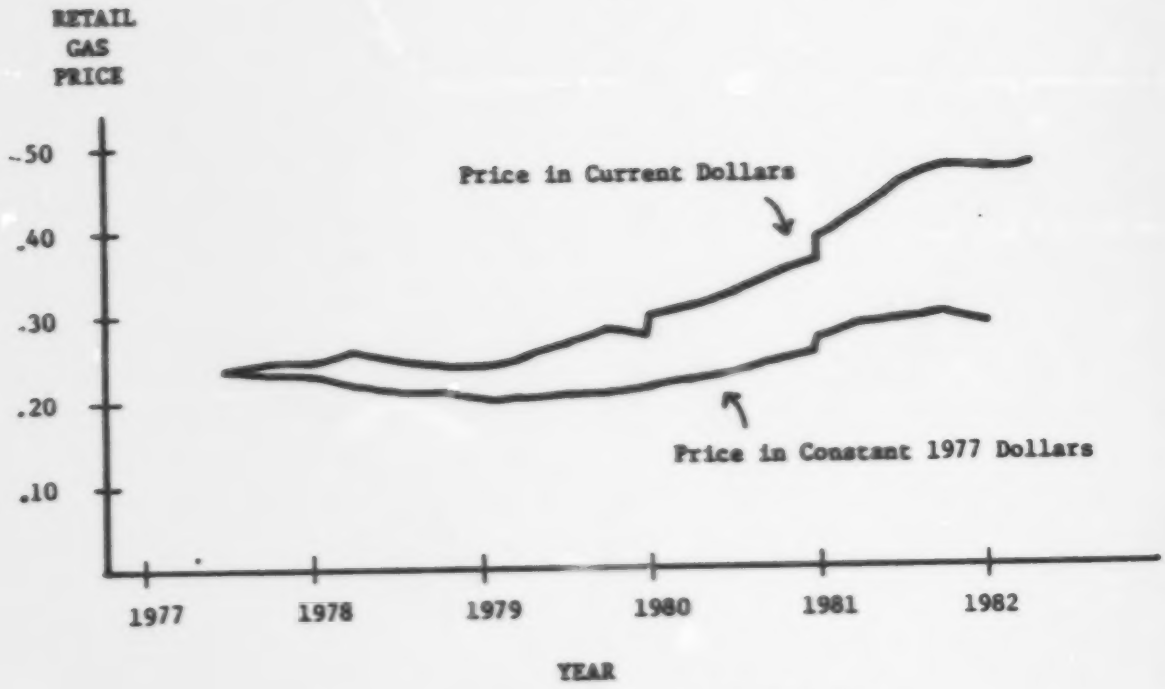


FIGURE 4-3 HISTORICAL CHANGES IN GASOLINE PRICE

employed, as it was considered to be the region most indicative of conditions in the Yukon*. As shown in Figure 4-4, the historical (1977 to 1980) level of retail trade has remained more or less constant in real terms. However, the retail trade was consistently above the historical trends, from May to December, 1981. In particular, the retail trade statistics, during the experimental period, exhibited an average 20% increase from the four-year control period average. At the same time, the gasoline sales ratio decreased significantly in October and gas volumes were not significantly higher in Whitehorse. This relationship is directly opposite to the historically measured relationship for the retail trade noted above. This result can be viewed as reducing the role of retail trade volume as an explanatory variable for the changes in gasoline sales in the evaluation period.

Intuitively, it would be expected that the level of retail trade and the population of Whitehorse would have the most significant impact on fuel sales in the city itself. For the control group (i.e., the rest of the Yukon), the biggest factor affecting fuel sales would be the monthly border crossings from Alaska to the Yukon. As such, fuel sales and therefore the fuel sales ratio, would not be expected to be predicted by any single exogenous factor. Since, however, the aim of the regression analysis was to identify factors which had the greatest influence on fuel sales in Whitehorse and the Yukon and

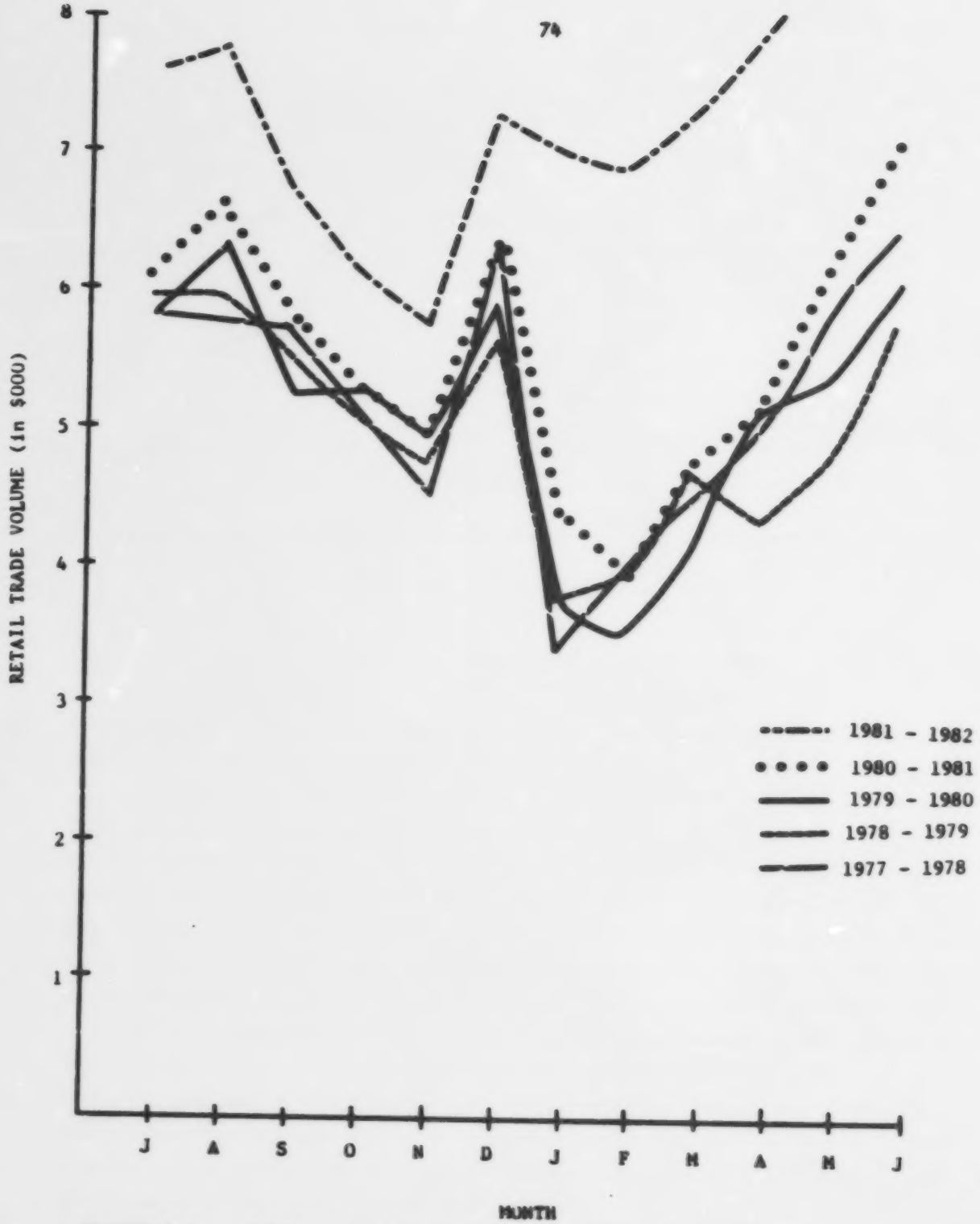


FIGURE 4-4 RETAIL TRADE: YUKON (Constant January, 1977 dollars)

then look at trends for these factors before and after the "Test and Tune" program, a single parameter correlation is probably valid but incomplete.

Basically from the analyses done, it must be said that of all the factors which could have affected the level of fuel sales in Whitehorse, none of them could be used to confidently explain a change in fuel sales from before to after the program.

Analysis of trends in the ratio of gasoline sales in Whitehorse to gasoline sales in the rest of the Yukon as shown in Tables 4-12 and 4-13 indicate that, for the period following "Test and Tune", only the month of October showed a statistically significant change for the ratio. The calculation of the difference in Whitehorse fuel sales resulting from this ratio change is as follows:

Yukon, October 1981 sales	5252 Klitres
Historical October ratio (1977-80)	0.62
Expected 1981 Whitehorse gas sales $\frac{(0.62 \text{ Yukon})}{1.62}$	2010 Klitres
Actual Whitehorse gas sales	1688 Klitres
% difference from expected	-16.0%

This difference is larger than that which would be expected based on the theoretical impact of the program.

It was expected that "Test and Tune" should have resulted in an immediate improvement in fuel efficiency for the inspected fleet which would gradually degrade (due to subsequet tampering) over the period of a few months. Given that 40% of the total vehicle kilometres travelled was supposedly affected by the program and a 5-10% improvement in specific vehicle fuel consumption would be expected, the overall effect of the program would be anticipated to be less than 5% for the first month following the program; gradually decreasing from that point onward.

Surprisingly, there was no significant change in fuel consumption for September when the biggest improvement would be expected. This fact, combined with the observation that no other significant change in fuel consumption occurred for any other month following the program, tends to make the measured 16% for October appear to be less than reliable. Therefore, it is not possible to conclude definitely that the program was the causal factor of the October drop in fuel sales. Extensive telephone interviews were undertaken with local Whitehorse retailers in an attempt to identify other explanatory variables, however, none were uncovered.

4.4 CONCLUSIONS

From the analysis presented in the preceeding section, the following conclusions are drawn:

- the post-program period analyzed (eight months) did not indicate any consistent statistically significant change from pre-program levels of demand,
- only one month (October) was found to have a statistically significant decrease in demand (16%) in the post-program period - no exogenous variables apart from the program itself were found to explain this decrease,
- on the basis of the data analyzed it cannot be concluded that the program had any measurable effect on Whitehorse fuel consumption.

5 DISCUSSION

From a purely statistical standpoint, it must be said that the normal fluctuations of the fuel sales and other exogenous factors in Whitehore and the Yukon are too great to identify changes in fuel sales at the 95% confidence level for the period following "Test and Tune". However, because the results of the program indicate that many vehicles did in fact improve in fuel efficiency as a result of proper maintenance, some reduction in overall fleet fuel consumption must have taken place.

If any conclusion is to be drawn from the previous analysis, it should be that the number of variables involved and the sensitivity of these variables to numerous other factors make traditional statistical analysis difficult, if not impossible.

It was felt that a better treatment of the data could be achieved if some of the perturbations in the data could be compensated for.

For example, Figure 5-1 shows the relative population trends for Whitehorse and the rest of the Yukon. For the five winter periods shown, it can be seen that the population of Whitehorse increased yearly with a minimum and maximum of approximately 15 000 and 18 500 respectively. The population of the rest of the Yukon, on the other hand, varied by only 500 or so.

Even though it has already been shown that population and gasoline sales do not correlate well, while the level of border crossings do, these facts must be interpreted as follows: While the population of Whitehorse may officially be lowest when gas sales are highest, the actual population of the city, bolstered by the tourist trade, is really at its highest as well. Intuitively, it is the people and the vehicles that they are driving who use the gasoline, therefore, all other factors being equal, gasoline sales should be directly proportional to population.

The sales ratio analysis will be adversely affected by the different trends in population for Whitehorse and the rest of the Yukon. If the population of Whitehorse tends to increase while that of the remainder of the Yukon remains constant, the ratio will increase.

Table 5-1 shows the sales ratios for October, November, December, January, February and March from 1977 to 1981 based on available sales data.

For the most part, the calculated ratios are relatively constant for the four winter periods considered with the exception of November and December of 1980. These months appear to be unusually high and low respectively, indicating that some unusual phenomena has changed the fuel sales in some sector. No explanation for this unusual shift has been found at this point.

TABLE 5-1

	Year			
	1977-78	1978-79	1979-80	1980-81
October	.66	.60	.62	.60
November	.98	.75	1.30	.69
December	1.10	1.10	.82	.91
January	.87	.75	.75	.69
February	1.27	.74	.82	.78
March	.94	.58	.66	.68
4th Quarter	.88	.77	.82	.72
1st Quarter	1.00	.68	.74	.71

Generally, there is a tendency for the ratios in 1977-78 to be higher than for other years with but a few exceptions. The ratios for the three periods following 77-78 are generally constant.

As mentioned previously, the trend to higher population in Whitehorse should cause the ratio to increase in the absence of changes in other areas. However, for the years under consideration it should be considered that new domestic cars have been getting better and better fuel consumption and there has been a noticeable increase in Whitehorse in the sales of smaller, Japanese-built cars which are generaly quite fuel efficient.

This would tend to offset the upward trend dictated by the population increase and might, in fact, be expected to bring about a decrease in the ratio, if the number of fuel-efficient cars outside Whitehorse were smaller than the number within the city.

In order to remove the population factor, the gasoline sales ratios were modified by normalizing to the 1977 population ratios. The resulting, adjusted gasoline sales ratios are shown in Table 5-2.

It may be seen that for the month of October, the population normalized ratios do not differ greatly from year to year. For other months, however, the ratios are more erratic.

In any event, the above table should represent accurate ratios for which all the exogenous factors which could affect fuel sales are the same for both Whitehorse and the rest of the Yukon.

TABLE 5-2

	Year			
	1977-78	1978-79	1979-80	1980-81
October	.66	.57	.57	.54
November	.98	.71	1.19	.63
December	1.10	1.05	.74	.83
January	.87	.72	.68	.63
February	1.27	.70	.75	.71
March	.94	.54	.61	.62
4th Quarter	.88	.73	.75	.65
1st Quarter	1.00	.64	.67	.65

If we forsake the analysis of variance technique for identifying significant differences in fuel sales following the "Test and Tune" program and instead perform a linear regression of the ratios versus year, good fits (i.e. $r^2 > .80$) are obtained for the month of October and the 4th quarter data. The calculated coefficients of determination, r^2, are .80 and .82 respectively. By using these projected ratios and comparing with actual data after the "Test and Tune" project, reductions in fuel sales attributable to the program of 5.1% in October and 2.6% for the quarter are obtained.

These figures would seem reasonable based on the theoretical impact of the test program. The coefficient of determination, r^2, for all other months is poor however, indicating that the scatter within the data is too great to permit a proper curve fit.

No statistical test of validity has been performed for the October and 4th quarter regressions it would be expected that the October result would be found to be significant at the 95% confidence level while the 4th quarter figure would not.

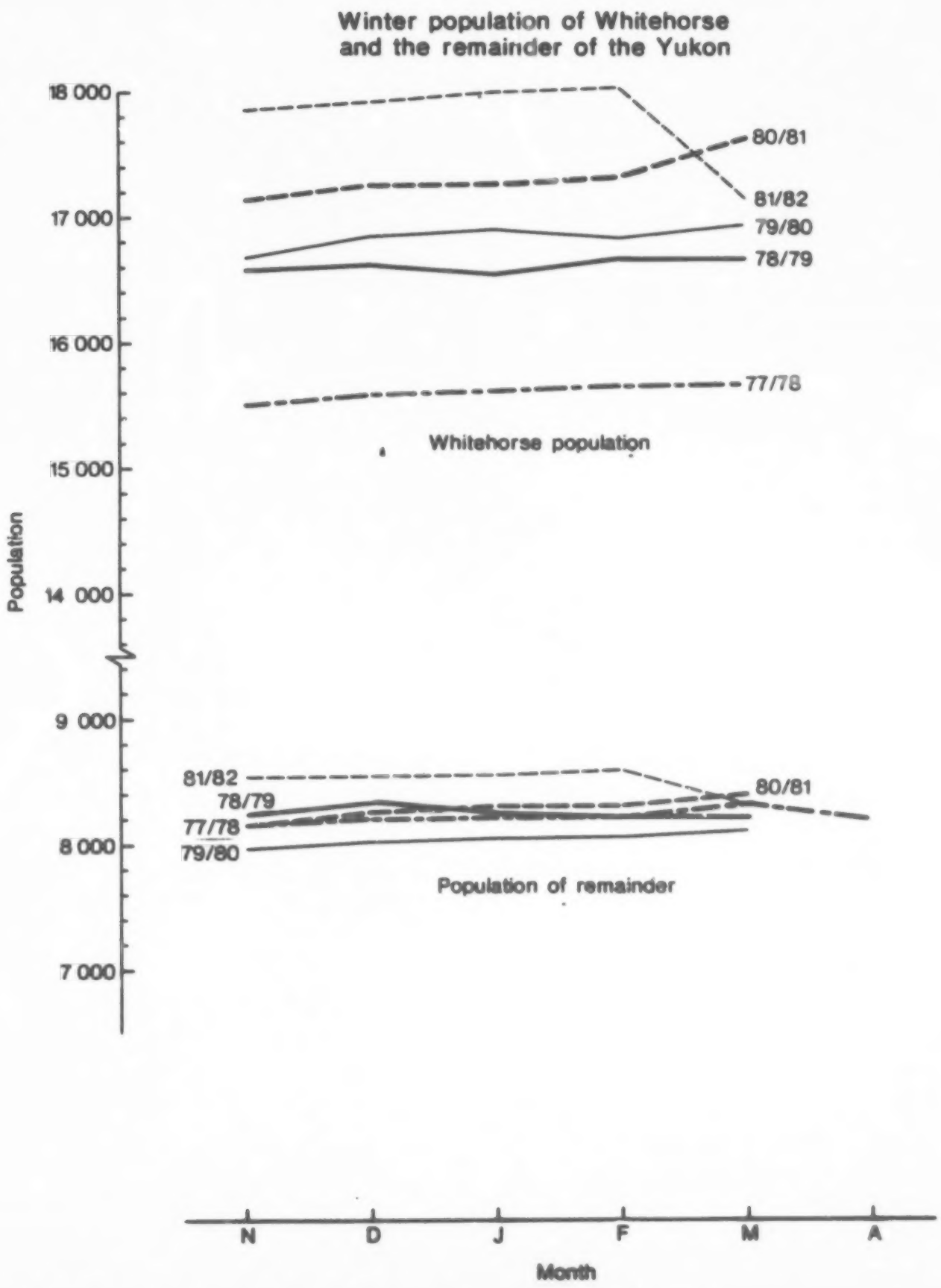
For the first three months of 1982, the comparison of projected and actual fuel sales is impossible as the r^2 values, obtained for these months based on previous years, indicate a very poor fit of the data.

This modified analysis technique however, does provide us with a calculated fuel savings for October of 1981 of 5.1% which is within the realm of possibility based on the capabilities of a "Test and Tune" program to reduce overall fleet fuel consumption. The calculated fuel savings for the final quarter of 1981 of 2.6% appears reasonable as well, although the validity of the result is less certain.

ACKNOWLEDGEMENT

Hickling-Partners Inc. would like to acknowledge the assistance of the following groups who provided basic data without which this study could not have been completed:

Whitepass Petroleum Services
Gulf Canada Ltd.
Imperial Oil Ltd.
The Government of the Yukon


Winter population of Whitehorse
and the remainder of the Yukon
18 000
17 000
16 000
15 000
14 000
9 000
8 000
7 000
Population
80/81
81/82
79/80
78/79
77/78
Whitehorse population
81/82
78/79
77/78
79/80
80/81
Population of remainder
N
D
J
F
M
A
Month

APPENDIX A

APPENDIX A

	Page
Figure 1 - Location of Whitehorse Sampling Station	84
Figure 2 - Location of the Federal Building and Sampling Station in Whitehorse	85
Meteorological Data	86
Example of Data Sheet	96
Example of Mailback Card	97
Example of Pamphlet	98
Results of Northwest Telecommunication Inc. Fleet Participation in the Program	99

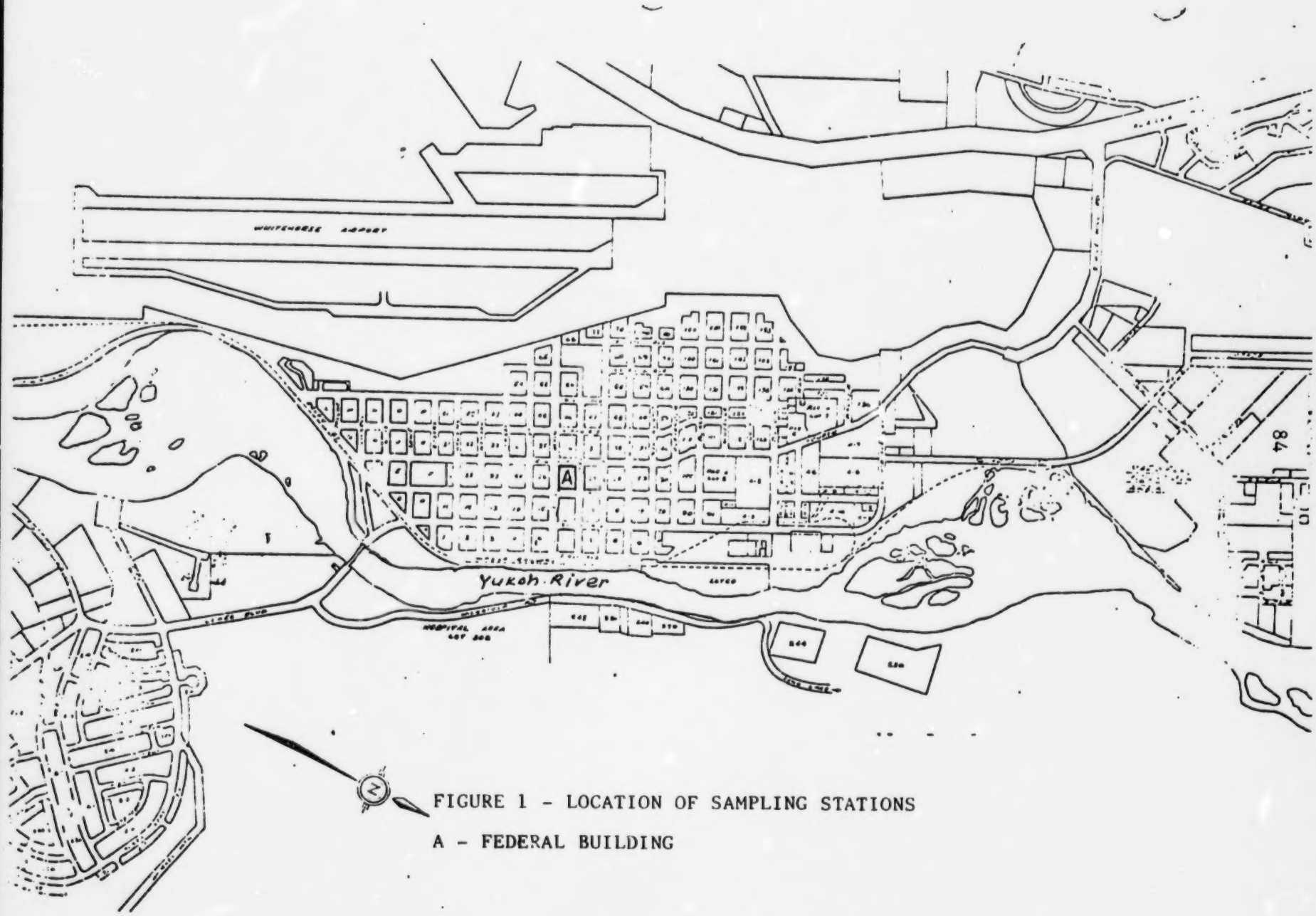


FIGURE 1 - LOCATION OF SAMPLING STATIONS

A - FEDERAL BUILDING

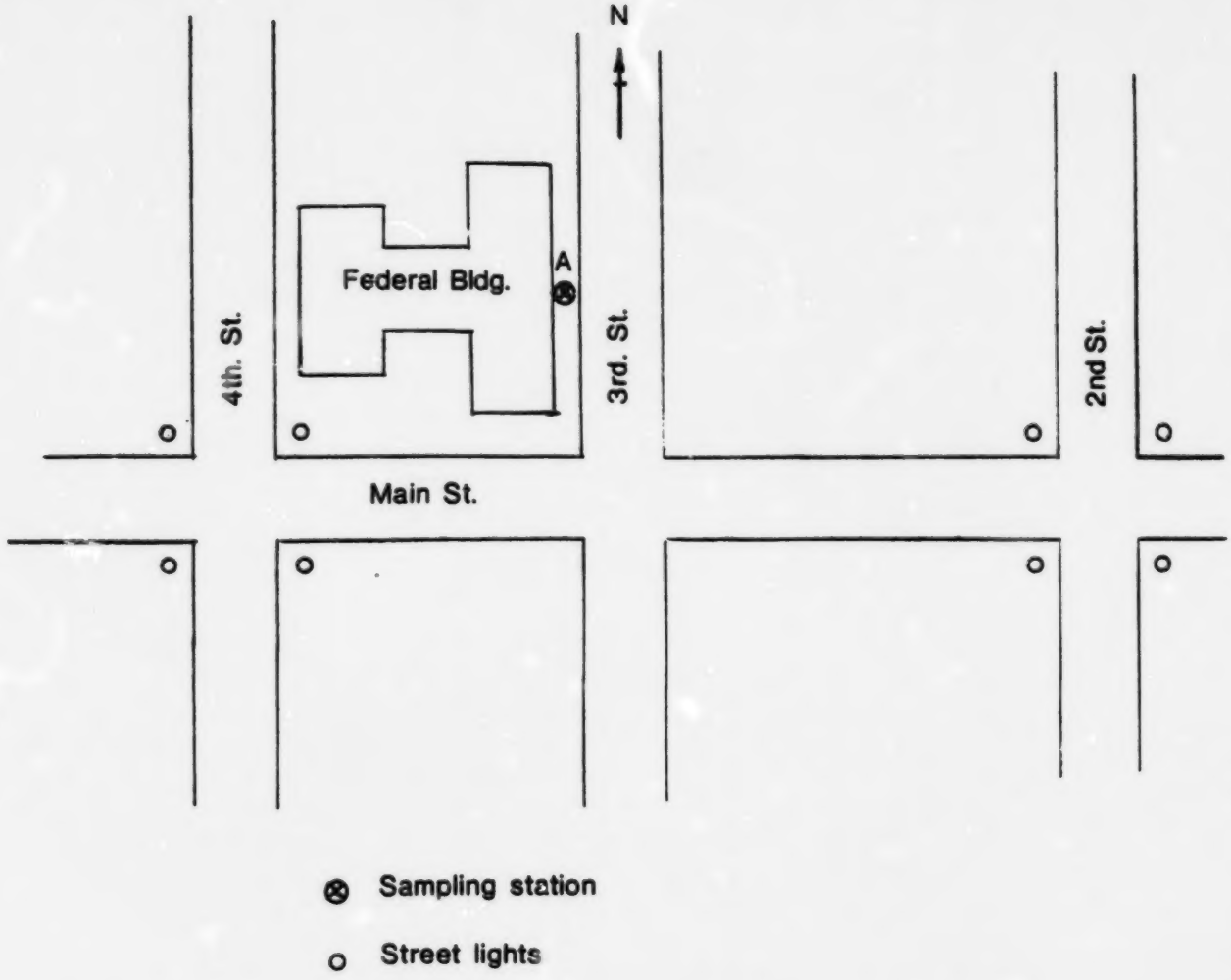


Figure 2. Location of the Federal building and sampling station in Whitehorse

TABLE 1 - AIR QUALITY AND METEOROLOGICAL DATA FOR THE CITY OF WHITEHORSE

	NOVEMBER 1978					DECEMBER 1978				
Day	CO ppm	Air temp. °C	Wind speed km/h	TxW/1000		CO ppm	Air temp. °C	Wind speed km/h	TxW/1000	
1	—	—	—	—		1.6	-4.9	26.3	7.05	S
2	—	—	—	—		0.7	-4.7	25.9	6.95	S
3	—	—	—	—		0.8	-4.8	9.3	2.49	S
4	—	—	—	—		4.5	-21.8	2.6	0.65	W
5	—	—	—	—		2.7	-21.0	2.9	0.73	S
6	1.4	-3.4	16.3	4.39	S	1.0	-20.6	20.6	5.20	S
7	1.2	-6.8	15.2	4.05	N	0.9	-7.0	25.0	6.65	S
8	1.9	-20.6	12.0	3.03	W	0.7	-1.2	18.3	4.97	S
9	1.0	-24.9	19.3	4.79	S	1.8	-3.5	18.0	4.85	S
10	1.8	-14.5	22.5	5.82	S	1.5	-14.0	12.5	3.24	S
11	1.2	-19.0	9.5	2.41	N	2.7	-23.0	7.8	1.95	S
12	0.6	-20.5	14.4	3.64	S	0.6	-14.6	20.5	5.30	S
13	0.8	-10.2	8.5	2.23	S	1.1	-6.8	23.2	6.18	S
14	1.4	-12.5	8.5	2.21	N	4.8	-16.7	7.3	1.87	S
15	0.6	-18.8	21.5	5.47	N	2.2	-14.3	7.1	1.84	N
16	2.3	-29.3	7.3	1.78	W	0.5	-19.6	18.0	4.56	N
17	3.0	-33.0	2.0	0.48	C	0.5	-31.9	18.8	4.53	S
18	2.3	-34.0	3.4	0.81	S	0.9	-20.3	29.1	7.35	S
19	0.5	-25.8	11.5	2.84	S	2.4	-22.4	17.7	4.44	S
20	1.1	-19.7	9.8	2.48	S	2.4	-24.9	10.7	2.65	N
21	0.9	-14.4	17.3	4.47	S	2.8	-29.6	5.0	1.22	N
22	3.6	-10.0	8.8	2.31	S	3.5	-32.0	18.3	4.41	S
23	1.4	-6.9	5.7	1.52	N	1.0	-17.1	25.1	6.42	S
24	1.2	-10.0	7.5	1.97	N	1.1	-21.5	5.5	1.38	N
25	2.2	-14.0	8.4	2.18	S	1.3	-32.6	2.3	0.55	N
26	0.2	-9.3	28.3	7.46	S	0.6	-35.5	3.3	0.78	S
27	0.5	1.5	20.3	5.57	S	2.2	-27.3	2.1	0.52	S
28	2.1	-0.6	13.5	3.68	S	1.2	-20.3	9.9	2.50	S
29	2.6	-6.4	4.0	1.07	S	1.7	-17.4	18.0	4.60	S
30	1.9	-6.1	3.6	0.96	S	0.8	-21.4	19.3	4.86	S
31						0.6	-27.7	14.0	3.43	S
Average	1.5	-14.8	12.0			1.7	-18.7	14.3		

Day	JANUARY 1979 CO ppm	Minimum temper. °C	Average wind speed km/h	TxW/1000	Wind dir.	FEBRUARY 1979 CO ppm	Minimum temperat. °C	Average wind speed km/h	TxW/1000
1	0.3	-35.1	14.0	3.33	S	2.3	-18.0	10.8	2.75 S
2	1.8	-37.3	3.9	0.92	N	1.1	-19.5	10.6	2.69 N
3	2.5	-38.5	0.3	0.07	S	0.4	-24.1	16.4	4.08 N
4	2.1	-32.1	5.2	1.25	S	0.2	-25.0	12.6	3.12 N
5	4.1	-34.0	1.3	0.31	S	0.9	-27.6	8.4	2.06 N
6	1.3	-36.0	1.8	0.43	S	0.5	-30.7	16.3	3.95 N
7	0.5	-31.4	3.4	0.82	S	1.0	-41.1	9.0	2.09 N
8	3.4	-35.9	2.8	0.66	S	1.1	-38.5	10.4	2.44 N
9	2.8	-34.3	2.7	0.64	S	1.1	-34.1	11.9	2.84 N
10	4.7	-34.8	4.5	1.07	S	0.9	-43.4	6.7	1.54 N
11	4.4	-37.3	1.0	0.24	S	0.5	-45.0	8.0	1.82 N
12	4.3	-41.3	1.1	0.25	S	2.6	-45.2	5.1	1.16 N
13	1.3	-39.4	7.1	1.66	S	1.2	-44.9	3.5	0.80 N
14	0.4	-34.5	21.4	5.10	S	2.1	-42.5	5.7	1.31 N
15	0.9	-27.2	30.0	7.57	S	0.8	-29.9	9.4	2.29 N
16	0.7	-18.2	25.5	6.30	S	0.9	-25.8	5.8	1.43 N
17	1.0	-9.4	17.3	4.56	S	1.2	-31.2	4.1	0.99 N
18	0.9	-7.1	23.6	6.28	S	0.4	-33.8	4.9	1.17 N
19	1.0	-6.3	20.2	5.39	S	1.3	-29.2	6.4	1.56 N
20	1.0	-13.6	12.2	3.16	S	—	—	—	—
21	0.3	-22.2	24.5	6.14	S	—	—	—	—
22	3.6	-17.5	14.5	3.70	S	—	—	—	—
23	1.7	-21.4	6.5	1.63	N	—	—	—	—
24	2.6	-26.9	2.5	0.62	S	3.2	-38.3	8.2	1.92 S
25	1.0	-23.2	20.4	5.10	S	1.5	-30.0	8.3	2.02 N
26	2.4	-19.8	5.1	1.29	N	2.5	-36.6	2.9	0.69 N
27	2.0	-20.7	11.1	2.80	S	1.8	-36.2	1.9	0.45 N
28	0.7	-21.8	5.0	1.26	S	1.5	-28.3	4.3	1.05 N
29	1.1	-26.5	10.9	2.69	N				
30	3.8	-32.5	4.5	1.08	S				
31	2.2	-21.0	12.7	3.20	S				
Mean	2.0	-27.2	10.3			1.3	-33.3	8.0	

Day	MARCH 1979 CO ppm	Minimum temperat. °C	Average wind speed km/h	T x W / 1000	NOVEMBER 1979 CO ppm	Minimum temperat. km/h	Average wind speed km/h	T x W / 1000
1	1.4	-23.8	5.4 N	1.35	2.1	-10.0	8.3	2.10 S
2	1.2	-22.3	8.6 N	2.16	1.1	-6.2	23.5	6.27 S
3	0.5	-19.5	6.0 N	1.52	0.7	-8.3	8.8	2.33 N
4	0.4	-20.7	5.8 N	1.46	0.3	-11.6	8.8	2.30 N
5	0.5	-13.1	16.2 S	4.21	1.6	-12.0	6.3	1.64 S
6	3.5	-3.8	14.7 S	3.96	0.9	-10.7	19.7	5.17 S
7	1.4	-3.6	8.3 S	2.24	1.7	-9.5	11.8	2.98 S
8	1.2	-13.3	21.3 S	5.53	2.0	-8.9	7.4	1.95 S
9	0.7	-3.5	26.3 S	7.09	2.4	-10.8	10.5	2.75 S
10	0.6	-6.0	16.0 S	4.27	1.6	-12.2	8.9	2.32 S
11	0.7	-18.4	8.8 S	2.24	1.2	-3.5	13.9	3.75 S
12	0.8	-5.0	24.4 S	6.54	0.6	0.4	20.3	5.55 S
13	0.7	-2.1	28.5 S	7.72	0.6	0.0	21.4	5.84 S
14	0.6	-2.0	19.0 S	5.15	-	-	-	-
15	1.5	-5.6	16.0 S	4.28	-	-	-	-
16	1.2	-8.6	19.2 S	5.08	-	-	-	-
17	0.5	-4.4	21.2 S	5.69	-	-	-	-
18	0.2	-2.1	25.8 S	6.99	-	-	-	-
19	0.3	0.9	34.3 S	9.39	-	-	-	-
20	1.1	-1.0	14.2 S	3.86	-	-	-	-
21	0.7	-8.3	13.3 S	3.52	-	-	-	-
22	1.3	-2.4	14.4 S	3.90	-	-	-	-
23	0.6	1.2	22.8 S	6.25	-	-	-	-
24	0.5	-3.4	14.7 N	3.96	-	-	-	-
25	0.4	-3.2	16.9 N	4.56	-	-	-	-
26	1.4	-13.8	3.6 S	0.93	-	-	-	-
27	0.5	-4.0	11.8 N	3.17	-	-	-	-
28	0.4	-7.1	13.0 N	3.46	-	-	-	-
29	0.8	-18.5	9.5 N	2.42	-	-	-	-
30	1.5	-24.2	4.9 N	1.22	-	-	-	-
31	1.3	-26.7	4.8 S	1.18				
Mean	0.9	-9.3			1.29	-4.4	12.6	

	DECEMBER 1979				JANUARY 1980			
Day	CO ppm	Minimum temperat. °C	Average wind speed km/h	TxW / 1000	CO ppm	Minimum temperat. °C	Average wind speed km/h	TxW / 1000
1	—	—	—	—	0.2	-26.5	14.0	3.45 N
2	—	—	—	—	0.7	-26.0	12.8	3.16 N
3	—	—	—	—	0.8	-28.0	13.0	3.19 N
4	—	—	—	—	4.5	-40.8	1.3	0.30 W
5	—	—	—	—	0.9	-41.6	18.1	4.19 S
6	—	—	—	—	0.4	-23.5	5.1	1.27 C
7	—	—	—	—	0.6	-21.3	14.2	3.57 N
8	—	—	—	—	1.4	-34.5	6.2	1.48 N
9	—	—	—	—	0.9	-24.7	13.4	3.33 W
10	—	—	—	—	1.2	-32.1	16.7	4.02 N
11	1.2	-25.4	22.8	5.65 N	2.6	-33.7	10.2	2.44 N
12	0.3	-27.8	15.2	3.73 N	0.8	-35.5	12.3	2.92 N
13	0.7	-31.0	19.0	4.60 N	1.4	-43.5	2.4	0.55 W
14	3.7	-39.6	3.3	0.77 W	1.4	-41.9	6.9	1.59 N
15	1.3	-36.0	15.3	3.63 S	0.9	-29.0	28.4	6.93 S
16	0.7	-33.5	7.9	1.89 N	2.7	-22.8	12.0	3.00 S
17	1.8	-27.2	7.1	1.75 N	0.8	-17.0	28.2	7.22 S
18	1.1	-23.4	33.6	8.39 S	—	—	—	—
19	2.4	-8.3	24.3	6.43 S	0.5	-6.4	33.3	8.88 S
20	1.3	-9.8	17.7	4.66 S	0.6	-9.5	24.0	6.32 S
21	1.7	-12.9	18.5	4.81 S	0.5	-3.5	32.4	8.73 S
22	1.2	-28.1	8.9	2.13 N	0.5	-0.5	31.0	8.45 S
23	0.7	-31.1	5.3	1.28 N	1.2	-16.2	17.2	4.42 W
24	1.9	-26.1	4.4	1.09 S	2.7	-29.1	1.6	0.39 W
25	0.4	-20.5	33.5	8.45 S	2.6	-33.8	3.8	0.91 N
26	0.9	-12.0	21.6	5.64 S	1.6	-35.6	2.8	0.66 N
27	2.0	-9.0	12.8	3.38 S	1.0	-34.4	1.8	0.43 S
28	3.7	-16.1	3.5	0.90 S	1.2	-27.9	6.5	1.59 N
29	1.3	-13.9	16.0	4.15 S	0.6	-19.0	11.1	2.82 N
30	0.5	-22.4	4.0	1.00 N	1.0	-26.3	3.5	0.86 N
31	0.6	-27.0	8.2	2.02 N	1.0	-22.8	11.2	2.80 S
Mean	1.4	-22.9	14.4		1.2	-26.4	13.2	

Day	FEBRUARY 1980				MARCH 1980			
	CO ppm	Minimum temperat. °C	Average wind speed km/h	TxW/1000	CO ppm	Minimum temperat. °C	Average wind speed km/h	TxW/1000
1	0.7	-15.1	35.4	9.13 S	0.5	-14.3	25.4	6.57 S
2	0.4	-2.4	27.1	7.33 S	0.4	-13.6	13.5	3.50 S
3	0.5	-6.6	23.5	6.26 S	0.8	-21.5	16.1	4.05 N
4	0.7	-8.5	26.4	6.98 S	0.7	-21.4	25.6	6.44 S
5	0.5	-5.0	26.9	7.21 S	2.0	-17.9	13.3	3.39 S
6	0.6	-4.2	32.0	8.60 S	2.8	-23.8	1.3	0.32 N
7	0.9	-7.1	24.8	6.59 S	3.6	-13.8	3.1	0.80 S
8	2.1	-20.9	12.7	3.20 S	0.6	-5.4	20.1	5.38 S
9	0.6	-10.8	34.2	8.97 S	0.6	-7.4	3.7	0.98 N
10	1.6	-5.6	12.3	3.29 S	0.6	-7.6	12.7	3.37 N
11	3.7	-14.0	1.9	0.49 N	1.6	-9.2	5.0	1.32 N
12	3.3	-16.8	0.9	0.23 N	1.3	-12.5	2.3	0.60 N
13	3.2	-19.6	2.2	0.56 S	1.2	-14.1	3.5	0.91 N
14	2.2	-18.0	3.2	0.82 N	2.0	-16.8	4.8	1.23 S
15	2.3	-26.2	3.0	0.74 N	0.8	-21.4	22.5	5.66 S
16	2.1	-29.5	1.3	0.32 N	0.5	-7.2	14.5	3.85 S
17	1.4	-32.1	3.3	0.79 N	1.2	-9.1	10.0	2.64 S
18	1.6	-25.7	5.6	1.38 N	1.2	-5.3	8.7	2.32 N
19	1.1	-17.7	12.6	3.22 S	1.3	-8.4	6.8	1.80 N
20	1.1	-20.3	23.9	6.04 S	0.9	-23.0	16.0	4.00 S
21	1.2	-18.1	25.5	6.50 S	1.7	-4.0	20.6	5.54 S
22	1.7	-20.1	20.9	5.29 S	0.6	-9.4	11.7	3.08 N
23	0.8	-5.4	27.8	7.44 S	0.5	-16.6	6.0	1.54 S
24	1.5	-2.0	16.4	4.44 S	0.8	-11.0	20.7	5.42 S
25	2.1	-6.0	4.9	1.31 S	0.8	-5.0	21.0	5.63 S
26	1.9	-6.2	3.5	0.93 N	0.8	-2.7	11.7	5.32 S
27	0.9	-2.8	17.8	4.81 S	0.8	-5.4	22.2	5.94 S
28	0.8	-1.2	18.4	5.00 S	0.9	-2.5	24.3	6.57 S
29	0.5	-8.4	16.0	4.23 N	0.9	-8.0	12.6	3.34 S
30					0.4	-3.8	28.2	7.59 S
31					1.3	-7.0	17.8	4.73 S
Mean	1.5	-13.0			1.1	-11.3	14.0	

NOVEMBER 1980

Day	CO ppm	Minimum temperat. °C	Average wind speed km/h	TxW/1000
1	0.9	-4.1	8.0 N	2.15
2	0.8	-4.1	18.8 S	2.90
3	0.8	-4.5	24.3 S	6.52
4	0.6	1.3	26.5 S	7.27
5	2.7	-4.6	5.8 S	1.56
6	1.6	-1.5	0.6 C	0.16
7	0.9	-2.3	2.4 N	0.65
8	—	—	—	—
9	—	—	—	—
10	1.9	-9.0	13.0 S	3.43
11	0.4	-9.0	25.6 S	6.76
12	0.7	-8.3	25.3 S	6.70
13	3.9	-9.2	5.5 N	1.45
14	2.4	-8.5	17.3 S	4.58
15	0.5	-4.1	29.9 S	8.04
16	0.1	-0.8	36.0 S	9.80
17	1.0	-3.2	21.0 S	5.67
18	1.0	-3.5	22.4 S	6.04
19	0.9	-3.5	21.4 S	5.77
20	1.9	-9.0	13.8 S	3.64
21	5.3	-16.6	3.8 S	0.97
22	1.0	-13.5	23.8 S	6.18
23	0.3	-2.9	25.3 S	6.83
24	0.6	-3.6	31.3 S	8.43
25	1.0	-3.6	19.7 S	5.31
26	0.9	-3.8	26.9 S	7.24
27	1.2	-1.3	23.7 S	6.44
28	1.3	-4.6	12.9 S	3.46
29	0.6	-12.7	24.5 N	6.38
30	0.5	-21.7	15.7 N	3.95
31				
Max	1.3	-6.28	18.5	

DECEMBER 1980

CO ppm	Minimum temperat. °C	Average wind speed km/h	TxW/1000
—	—	—	—
—	—	—	—
3.0	-34.5	3.8	0.91 S
2.2	-34.5	8.7	2.07 S
2.9	-26.3	11.4	2.81 S
0.9	-26.3	9.5	2.34 N
0.5	-24.8	18.0	4.47 N
3.1	-36.6	8.0	1.89 N
3.8	-41.0	2.5	0.58 W
1.2	-37.8	9.0	2.12 N
4.6	-32.3	7.8	1.88 N
3.5	-32.5	14.0	3.37 N
1.5	-28.1	12.8	3.13 N
0.7	-11.0	22.7	5.95 S
7.0	-20.7	6.0	1.51 S
1.4	-27.1	19.1	4.70 N
1.6	-34.0	16.1	3.85 N
3.2	-39.9	6.8	1.59 N
2.2	-39.4	11.2	2.62 N
1.4	-40.2	7.7	1.79 N
0.5	-38.7	12.4	2.91 N
2.1	-38.7	5.4	1.27 N
6.3	-40.6	0.3	0.07 W
3.6	-42.0	1.9	0.44 N
0.3	-31.0	11.9	2.88 N
0.4	-30.3	19.8	4.81 N
1.7	-44.3	6.5	1.49 N
0.5	-45.0	2.8	0.64 N
1.1	-33.4	11.3	2.71 N
1.2	-21.0	25.3	6.38 S
0.8	-4.1	31.1	8.36 S
2.2	-32.3	11.2	

Day	JANUARY 1981 CO ppm	Minimum temperat. °C	Average wind speed km/h	T x W / 1000	Wind dir.	FEBRUARY 1981 CO ppm	Minimum temperat. °C	Average wind speed km/h	T x W / 1000	Wind dir.
1	0.4	-5.5	32.7	8.75	S	0.3	-6.0	32.2	8.00	S
2	1.3	-0.4	23.5	6.41	S	1.0	-3.7	21.6	5.88	S
3	0.5	0.3	22.0	6.03	S	1.4	-7.0	18.3	4.87	S
4	0.4	-0.3	20.5	5.58	S	1.4	-11.8	12.7	3.32	S
5	4.3	-12.3	2.1	0.55	S	1.2	-14.3	5.4	1.37	S
6	1.3	-9.0	19.3	5.10	S	1.6	-18.1	14.3	3.65	S
7	0.9	-4.5	27.7	7.44	S	3.0	-10.4	2.1	0.55	C
8	4.3	-14.7	11.6	3.00	S	0.5	-11.4	10.4	2.72	N
9	1.3	-12.0	24.4	6.37	S	1.8	-24.2	11.4	2.84	S
10	0.7	-6.7	21.1	5.62	S	1.7	-12.0	14.8	3.86	S
11	0.5	-0.4	24.5	6.68	S	1.0	-15.5	12.6	3.24	N
12	5.5	-11.4	11.1	2.90	S	1.3	-21.2	9.4	2.37	N
13	0.9	-11.6	21.5	5.62	S	1.4	-19.9	6.3	1.59	N
14	0.4	-1.2	36.0	9.78	S	1.0	-20.1	8.3	2.10	N
15	0.4	3.3	35.3	9.75	S	1.0	-24.6	10.5	2.61	N
16	1.2	1.4	23.2	6.37	S	3.2	-33.7	1.1	0.26	C
17	0.8	-2.1	21.2	5.74	S	1.1	-29.5	6.2	1.51	N
18	0.4	-0.5	26.3	7.17	S	1.6	-18.7	7.2	1.83	N
19	0.9	-1.3	28.5	7.74	S	2.2	-19.2	6.0	1.52	S
20	1.6	-7.7	15.4	4.09	S	1.4	-19.1	20.0	5.08	S
21	0.8	-7.6	24.8	6.58	S	0.5	-5.3	27.1	7.25	S
22	2.0	-3.4	16.3	4.39	S	0.6	-11.5	12.3	3.22	S
23	1.1	-3.6	23.3	6.28	S	1.8	-17.7	3.9	1.00	S
24	1.5	-7.2	18.8	5.00	S	1.9	-22.5	11.4	2.86	S
25	0.4	-10.9	30.2	7.92	S	1.3	-13.1	22.0	5.72	S
26	1.1	-14.2	29.0	7.51	S	1.0	-12.4	25.6	6.67	S
27	1.3	-14.7	14.5	3.75	S	1.6	-12.6	24.2	6.30	S
28	3.6	-22.4	4.3	1.08	N	3.5	-10.4	12.7	3.34	S
29	1.4	-25.5	24.5	6.06	S					
30	1.1	-15.7	36.9	9.49	S					
31	0.8	-10.5	26.3	6.90	S					
Mois	1.4	-7.5	22.5			1.5	-16.1	13.2		

MARCH 1981

Day	CO ppm	Minimum temperat. °C	Average wind speed km/h	T x W / 1000		CO ppm	Minimum temperat. °C	Average wind speed km/h	T x W / 1000	
1	1.6	-8.0	17.5	4.64	S	0.3	-4.9	19.1	5.12	S
2	1.0	-6.6	20.1	5.35	S	0.8	-5.8	22.0	5.88	S
3	—	—	—	—		1.0	-6.1	23.5	6.27	S
4	—	—	—	—		0.5	-2.3	26.4	7.15	S
5	—	—	—	—		1.4	-10.0	11.8	3.10	S
6	2.8	-11.6	17.1	4.47	S	2.7	-16.7	9.7	2.49	S
7	1.9	-22.0	1.1	0.28	S	1.3	-18.5	13.3	3.38	S
8	0.4	-8.2	21.7	5.74	S	0.2	-7.0	31.2	8.30	S
9	0.5	-1.3	23.7	6.44	S	0.9	-2.6	23.4	6.33	S
10	0.7	-4.0	18.3	4.92	S	1.5	0.7	22.6	6.19	S
11	0.4	-2.4	29.3	7.93	S	0.7	-0.4	19.5	5.32	S
12	1.2	0.3	14.7	4.01	S	1.6	-5.8	15.7	4.20	S
13	0.7	-2.0	19.8	5.37	S	3.3	-11.3	3.5	0.92	S
14	0.5	-3.0	22.6	6.10	S	0.6	-7.9	6.7	1.78	N
15	0.2	-0.3	21.2	5.78	S	0.2	-5.8	5.5	1.47	N
16	1.8	-5.0	9.5	2.55	S	1.2	-6.6	5.8	1.53	S
17	0.9	-7.7	21.2	5.62	S	0.8	-7.2	11.0	2.92	N
18	0.9	-2.8	24.5	6.62	S	1.0	-8.7	8.1	2.14	N
19	1.1	-6.1	19.5	5.20	S	1.3	-9.4	6.9	1.82	N
20	1.1	-9.4	10.0	2.64	N	0.9	-11.4	5.3	1.39	N
21	0.8	-5.9	10.3	2.75	N	0.5	-12.7	6.5	1.69	N
22	0.5	-9.4	25.3	6.67	S	0.3	-10.9	6.7	1.76	S
23	0.4	-8.5	22.5	5.95	S	0.8	-7.4	25.4	6.75	S
24	1.5	-3.6	16.3	4.39	S	0.8	-6.6	26.8	7.14	S
25	1.5	-3.6	3.9	1.05	N	1.9	-8.7	10.9	2.88	N
26	0.8	-5.3	21.5	5.76	S	1.5	-17.7	18.4	4.70	S
27	2.4	-3.4	13.9	3.75	S	0.9	-3.4	26.8	7.23	S
28	1.2	-9.3	7.6	2.00	N	4.4	-8.2	3.9	1.03	S
29	1.1	-8.8	7.0	1.85	S	0.7	-9.5	6.7	1.77	N
30	1.3	-5.3	9.7	2.60	S	0.8	-9.1	27.2	7.18	S
31	1.2	-6.8	7.9	2.10	N					
Mean	1.1	-6.1	16.4			1.2	-8.1	15.0		

NOVEMBER 1981

DECEMBER 1981

Day	CO ppm	Minimum temperat. °C	Average wind speed km/h	TxW/1000		CO ppm	Minimum temperat. °C	Average wind speed km/h	TxW/1000	
1	1.4	-8.2	23.2	6.14	S	0.9	-41.9	4.4	1.02	N
2	1.6	-13.0	17.4	4.52	S	0.6	-42.5	6.5	1.50	N
3	0.6	-7.0	30.5	8.11	S	0.7	-42.6	2.0	0.46	S
4	3.7	-12.7	13.2	3.44	S	1.6	-42.0	8.4	1.94	S
5	0.9	-3.4	18.8	4.96	S	0.7	-33.1	21.0	5.04	S
6	1.8	-20.9	7.3	1.84	S	0.7	-32.2	19.5	4.70	N
7	1.8	-26.3	0.7	0.17	S	1.3	-42.5	8.1	1.87	N
8	0.8	-19.2	9.5	2.41	S	0.8	-44.0	8.9	2.04	N
9	1.0	-19.7	7.0	1.77	S	0.4	-35.2	2.9	0.69	N
10	1.3	-21.8	6.5	1.58	N	0.5	-29.2	0.3	0.07	N
11	1.6	-32.3	15.5	3.73	S	1.3	-23.9	2.2	0.55	N
12	0.9	-19.5	21.4	5.42	S	1.2	-26.3	3.0	0.74	N
13	0.9	-23.6	15.3	3.82	S	0.9	-21.0	14.4	3.63	N
14	2.2	-28.4	4.8	1.17	S	2.3	-37.1	4.2	0.99	N
15	1.2	-20.7	18.2	4.59	S	2.6	-40.5	19.1	4.44	S
16	0.7	-15.2	31.5	8.12	S	0.6	-30.1	18.8	4.57	S
17	0.7	-5.0	32.5	8.71	S	0.8	-34.5	7.8	1.86	N
18	1.0	-2.7	26.2	7.08	S	1.3	-39.7	4.1	0.96	N
19	1.7	-15.5	7.8	2.01	S	0.9	-30.5	13.1	3.18	N
20	2.3	-9.0	5.2	1.37	S	1.8	-40.2	5.4	1.26	N
21	3.8	-12.1	9.6	2.50	S	2.5	-42.5	2.6	0.60	N
22	5.5	-22.8	2.3	0.58	S	2.4	-41.4	3.2	0.74	N
23	1.3	-17.3	22.2	5.68	S	1.4	-41.7	2.7	0.02	N
24	1.3	-18.3	16.6	4.23	S	0.4	-38.8	4.7	1.13	N
25	0.2	-11.8	12.0	3.13	S	1.3	-39.0	6.1	1.43	N
26	0.2	-17.8	16.9	4.31	N	2.1	-41.1	3.0	0.70	N
27	0.2	-29.5	13.3	3.24	N	0.8	-41.3	6.5	1.51	N
28	0.8	-39.1	4.4	1.03	N	1.2	-37.7	12.6	2.96	S
29	1.1	-41.3	1.5	0.35	N	1.3	-21.0	25.0	6.30	S
30	2.2	-41.2	1.1	0.25	N	1.9	-26.6	16.8	4.14	S
31	1.3	-42.9	6.5	1.50	N	1.0	-29.9	0.6	0.15	N
Mean	1.5	-20.4	13.5			1.2	-35.6	8.3		

Day	FEBRUARY 1982 CO ppm	Minimum temperat. °C	Average wind speed km/h	TxW/1000	MARCH 1982 CO ppm	Minimum temperat. °C	Average wind speed km/h	TxW/1000
1	1.6	-22.5	3.8	0.95 S	1.8	-37.7	5.8	1.36 W
2	1.4	-16.5	11.7	3.00 S	1.7	-27.7	4.3	1.05 N
3	—	—	—	—	2.9	-32.4	5.3	1.28 S
4	—	—	—	—	2.1	-19.6	17.5	4.43 S
5	—	—	—	—	5.1	-24.4	1.5	0.37 W
6	—	—	—	—	2.6	-21.6	3.0	0.75 N
7	—	—	—	—	0.9	-10.4	3.9	1.02 N
8	1.0	-10.6	18.2	4.78 S	1.0	-10.3	8.3	2.18 N
9	0.6	-8.2	15.5	4.10 N	1.1	-13.1	15.8	4.11 S
10	0.9	-14.0	13.3	3.44 N	1.3	-9.3	12.5	3.30 N
11	1.3	-22.1	13.3	3.34 N	2.0	-19.2	7.3	1.85 S
12	3.5	-31.9	8.0	1.93 N	—	—	—	—
13	1.9	-36.8	2.2	0.52 S	0.7	-15.2	11.5	2.96 N
14	0.4	-26.7	23.9	5.89 S	1.6	-28.0	2.5	0.61 W
15	0.5	-16.6	31.5	8.08 S	2.0	-23.3	6.1	1.52 N
16	1.5	-15.0	18.0	4.64 S	1.6	-15.9	7.2	1.85 N
17	2.7	-20.5	16.3	4.12 S	1.2	-16.3	20.5	5.26 S
18	1.5	-14.7	5.8	1.50 N	0.6	-2.7	24.8	6.70 S
19	3.0	-27.3	6.6	1.62 N	1.7	-8.1	19.0	5.03 S
20	0.5	-25.1	18.3	4.54 N	0.5	-2.4	25.3	6.85 S
21	0.4	-27.5	22.0	5.40 N	0.2	-3.6	26.2	7.06 S
22	0.8	-29.9	21.3	5.18 N	1.3	-4.9	10.0	2.68 S
23	1.0	-30.6	16.9	4.10 N	1.2	-14.6	10.0	2.58 S
24	1.2	-33.9	11.9	2.85 N	—	—	—	—
25	1.2	-33.3	14.0	3.36 N	—	—	—	—
26	2.1	-32.5	10.0	2.41 N	—	—	—	—
27	3.0	-39.5	4.6	1.07 N	—	—	—	—
28	2.3	-39.7	4.0	0.93 N	—	—	—	—
29					—	—	—	—
30					—	—	—	—
31					—	—	—	—
Mean	1.5	-25.1	13.5		1.6	-16.4	11.3	

SAMPLE DATA SHEET

Owner PATCHETT . S.

1. MODEL YEAR 19(7)(2)

2. MANUFACTURER
GM - 1
Ford - (2)
Chrysler - 3
AMC - 4
Japanese - 5
European - 6
Other - 7

3. MODEL
Sub - 1
Comp - 2
Inter - (3)
Full - 4
L.D.Tr. - 5
H.D.Tr. - 6

4. ODOMETER (1)(0)(7)(3)(9)(3)

5. UNITS
Km - 0
Mi - (1)

6. NO. CYLINDERS (8)

7. TRANSMISSION
Manual - 0
Automatic - (1)

8. SPEEDS (3)

9. DIST/YEAR (1)(0)(0)(0)(0)

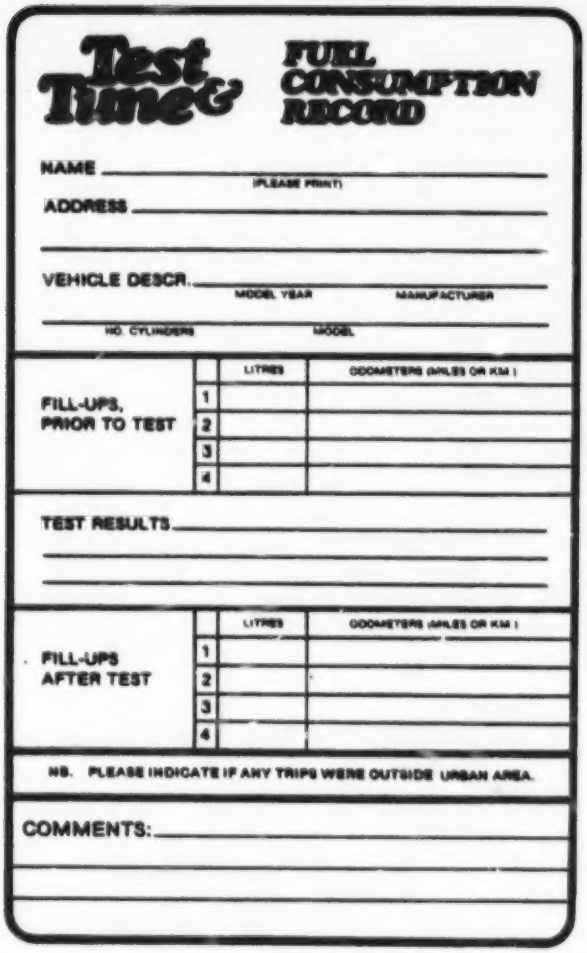
10. UNITS
Km - 0
Mi - (1)

11. FUEL
Regular Pb - (1)
Premium Pb - 2
Regular U/L - 3
Premium U/L - 4
Diesel - 5
Other - 6

		Before		After
12.	2500 RPM % CO	(0.3)	20.	(0.7)
13.	2500 RPM HC	(0)(2)(0)(0)	21.	(0)(1)(4)(0)
14.	IDLE RPM	(0)(6)(5)(0)	22.	(0)(6)(5)(0)
15.	IDLE % CO	(0.4)	23.	(1.5)
16.	IDLE HC	(1)(5)(5)(0)	24.	(0)(4)(0)(0)
17.	2500 RPM SPEC No - 0 Yes - 1	(1)	25.	(1)
18.	IDLE SPEC	(1)	26.	(1)
19.	ADJUSTED	(1)		

27. E.G.R. Equipped
No - (0) Yes - 1

28. E.G.R. Operating
No - 0 Yes - 1



Test & Time

FUEL CONSUMPTION RECORD

NAME _____ (PLEASE PRINT)

ADDRESS _____

_____

VEHICLE DESCR. _____ MODEL YEAR MANUFACTURER

_____ NO. CYLINDERS MODEL

		LITRES	ODOMETERS (MILES OR KM)
FILL-UPS, PRIOR TO TEST	1		
	2		
	3		
	4		

TEST RESULTS _____

_____

_____

		LITRES	ODOMETERS (MILES OR KM)
FILL-UPS AFTER TEST	1		
	2		
	3		
	4		

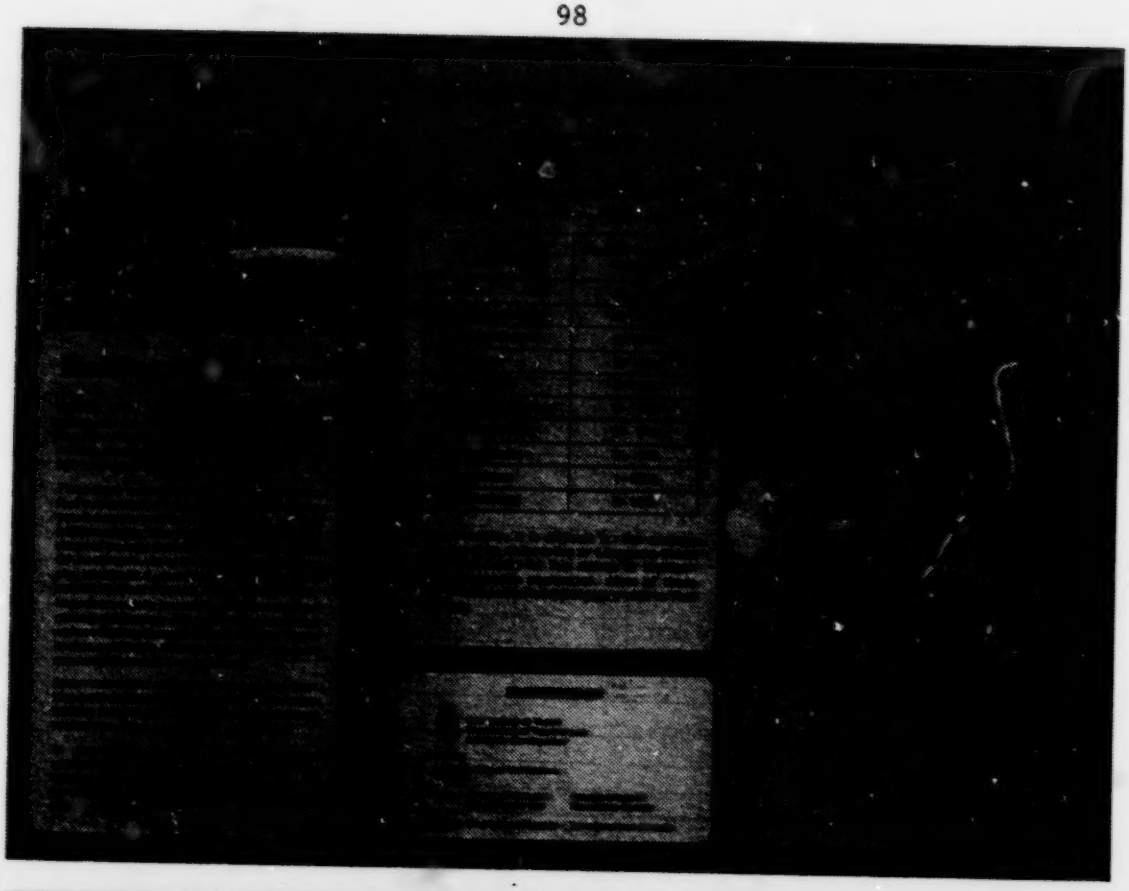
NB. PLEASE INDICATE IF ANY TRIPS WERE OUTSIDE URBAN AREA.

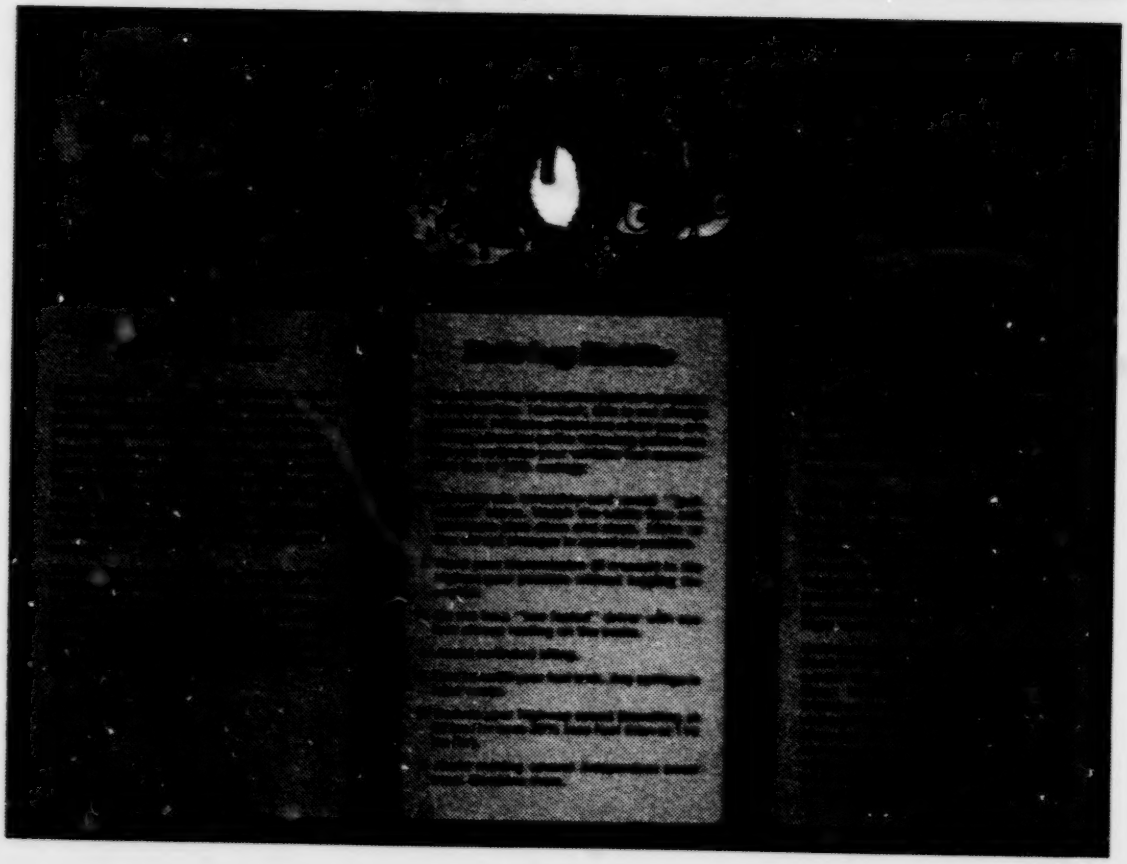
COMMENTS: _____

_____

_____

EXAMPLE OF MAIL-BACK CARD





Environment Canada Environnement Canada 99

MEMORANDUM NOTE DE SERVICE

DATE 1982 04 26

FROM: / DE:
Rob McCandless
Manager, Environmental
Assessments & Appraisals
EPS - Yukon Branch

Our file / Notre référence
5000.5-3/5

TO: / À:
Mr. John Polak, Head
New Vehicles Section
Air Pollution Control Directorate
Ottawa, Ontario

Your file / Votre référence

SUBJECT: / SUJET: Follow-up to Test and Tune Program

You will remember our phone conversation on April 26, regarding fuel consumption improvement in the Northwest Telecommunication Inc. fleet. I have attached copies of Doug Davidge's notes on the vehicles tested in comparison to a non-adjusted 'control' group. The data are scanty, but the 10% improvement in fuel economy seems valid. This company's vehicle records are probably the best in the north, and they make the case for regular use of the CO metres.

I have also attached a draft letter to go to various fleet operators above Colin Wykes' signature to encourage greater use of the exhaust analysers within the community. Phone me with your comment on this draft; we'd like to see it mailed in the next couple of weeks.

Rob McCandless

RM/mm

Att.

DOE-1071 (Rev. 1/73) F-2013

1982 04 16

Colin Wykes
Director
EPS - Yukon Branch

5000.5-3/5

- DRAFT -

Distribution

Test and Tune Program, 1981

You will remember our participation in the intergovernmental program "Test and Tune", which sought to reduce gasoline consumption and pollutant emissions from vehicles through carburator adjustments. Northwest Telecommunications Inc. participated in these tests and generously provided us with gas consumption figures for selected vehicles.

In July, 1981, as part of the Test and Tune Program in Whitehorse, 67 NorthwesTel vehicles were checked for carbon monoxide and hydrocarbon exhaust emissions. From this fleet, 50 units were selected to determine if any reduction in fuel consumption occurred as a result of the test program.

These 50 vehicles were then divided into two groups of 25, Group A being those vehicles that received adjustments to the carburator and Group B, those vehicles not receiving adjustments to the carburator.

Fuel consumption records for a three month period before the test date were compared to a three month period after.

An arithmatic mean for the before and after period for both groups showed about a 10% reduction in fuel consumption in Group A, which can be attributed to the adjustments made by Test and Tune. Group B showed no improvement in fuel consumption.

This simple comparison shows there can be considerable savings for private industry and government fleets if managers insure their vehicles are tuned and maintained on a regular basis. Since NorthwesTel spends in excess of $150,000.00 a year for fuel for their Yukon vehicles, this could mean a significant reduction in fuel costs.

We believe that everyone, particularly fleet operators, should make use of exhaust analysers to tune their vehicles, since there is an obvious economic benefit and a reduction in carbon monoxide and hydrocarbon emissions.

.../2

EPS would like to thank Mr. Parker and Mr. McQuaig of NorthwesTel for their interest and providing us with the necessary information.

Please contact this office if you have any comments.

Colin Wykes
Director
EPS - Yukon Branch

DISTRIBUTION:

John Polak - Mobile Sources, Division, EPS - Ottawa
Dave Poon - Senior Project Engineer, EPS - Vancouver
Bob Collins - Manager, Demonstrations Program, YTG - Whitehorse
Mel Orecklin - Director, EMR - Whitehorse
John Hudson - Manager, Civil Engineering, DPW - Whitehorse
Rick Moulrooney - Financial Services, RCMP - Whitehorse
W.A. Dunbar - General Manager, NorthwesTel, Whitehorse
Jack Gwartney - Equipment Maintenance Supervisor, DIAND - Whitehorse

The following list is the average litres/100 km for Group A:

Unit #	April, May, June	Aug, Sept, Oct.
1769 - 77	98.2	29.1
1774 - 77	38.4	29.8
1786 - 77	33.6	40.1
1801 - 78	23.2	20.9
1805 - 78	9.6	23.5
1810 - 78	16.8	27.3
1816 - 78	26.5	18.3
1827 - 78	28.0	20.1
1926 - 78	18.0	52.6
1964 - 79	18.8	14.7
1973 - 79	26.4	21.8
1975 - 79	22.1	20.5
1976 - 79	19.4	19.9
1978 - 79	19.5	13.8
NL172 - 79	5.3	16.5
NL192 - 80	13.5	11.5
N2052 - 80	1.8	3.2
N2071 - 80	39.8	26.4

The following list is the average litres/100 km for Group B:

Unit #	April, May, June	Aug, Sept, Oct.
1445 - 73	7.8	17.7
1616 - 75	54.4	96.3
1647 - 75	28.6	169.5
1674 - 75	20.9	63.3
1807 - 78	7.8	22.9
1812 - 78	38.2	26.4
NL155 - 79	9.8	17.8
NL191 - 80	11.7	17.0
N2049 - 80	14.7	22.0
2054 - 80	31.2	26.2
N2056 - 80	36.2	36.5
N2066 - 80	10.5	43.4

Group A

April, May, June 18 units (a) $\bar{x}$ = 25.5

selected units(x)(11)(b) $\bar{x}$ = 25.1

Aug, Sept, Oct, 18 units (a) $\bar{x}$ = 22.8

selected units(x)(11)(b) $\bar{x}$ = 19.8

Reduction in fuel consumption (a) = 10%

(b) = 21%

Amount of gas/year 7%

Group B

April, May, June 12 units $\bar{x}$ = 22.6

selected units (x)(9)$\bar{x}$

Aug. Sept. Oct. 12 units $\bar{x}$ = 46.6

selected units (x)(9)$\bar{x}$ = 28.8

Overall averages (6 months) for selected units - $\bar{x}$ = 32.05

Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

Yukon
Department of Economic Development

Project Summary:
TEST AND TUNE, Car Clinic

Canada/Yukon Conservation and Renewable Energy Demonstration Program

Project No.
3766-4-10

Project Locations: Whitehorse, Faro, Haines Junction, Watson Lake, Dawson City

Project Manager:
Doug Davidge

Date:
November 1, 1983

Technology:
Conservation

Status:
Completed

Sectors:
Transportation

Jurisdiction:
Yukon

Purpose:

1. To evaluate the effects on gasoline consumption following proper carburetor setting.
2. To measure the effects on vehicle emissions following proper carburetor setting.

Description:

Yukon motorists were offered a free 12 week clinic in which carburetors were set to manufacturers specifications, tires were inflated to recommended specifications and motorists were given tips on energy efficient driving.

Contributors:

Environment Canada	$15,000
Transport Canada	18,000
Canada/Yukon	54,000
	$87,000

Expected Benefits:

1. A 4 to 10 per cent decrease in fuel consumption.
2. A 10 to 90 per cent decrease in CO emissions.

For More Information Contact:

Doug Davidge
EPS
Federal Building
Whitehorse
667-6487

David Arseneault
Energy Branch
Government of Yukon
Box 2703, Whitehorse, Y1A 2C6
667-5471

Monitoring:

1. A mail back survey of randomly selected vehicle owners in which drivers recorded fuel consumption before and after the clinic.
2. Monitoring of selected vehicles whereby an in line fuel meter was connected and consumption measured through a fixed course before and after tuning.
3. Monitoring of atmospheric CO levels in Whitehorse.
4. An evaluation of before and after fuel consumption in Whitehorse.

Evaluation:

1. Four vehicle owners responded in the survey - statistically insignificant
2. Exogenous variables and the small number of people involved in the fixed course produced no reliable results.
3. In the five month period following the car clinic there was a 35 per cent reduction in CO levels attributed to the program.
4. Analysis of fuel consumption records did not provide evidence of a statistically significant drop in fuel demand.

Conclusions:

The test and tune project was really a two part study designed to measure the effects from carburetor adjustments on fuel efficiency and vehicle emissions. The study on fuel efficiency was ill-designed in that not enough pre-project consideration was given to a wide variety of exogenous variables. The expected fuel savings were in the order of 3 to 5 per cent. There was in fact a 3.76 per cent reduction in fuel consumption but given the unknown effects of these exogenous variables the observed reduction cannot reliably be attributed to the project. The study on vehicle emissions, on the other hand, reliably pointed to a 35 per cent reduction in atmospheric CO as a result of proper tuning of the carburetors of between 40 and 50 per cent of the vehicles regularly driven in Whitehorse's winter. The results outlined here encapsulate the findings of the reports on Test and Tune done by Environment Canada and Hickling-Partners Inc.